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Proceedings of the workshop on biomass-based cogeneration

3–5 June 1996

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Pradeep Dadhich

Foreword

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(Director, Science and Technology Division, and

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Foreword

Faced with growing imbalances between the ever-increasing demand for energy and the rapidly declining supply of its non-renewable sources, the world today must and will have to look for alternative energy options In this context, cogeneration the simultaneous production of heat and power (two forms of energy), using one fuel has gained increasing global importance.

Recognizing the significance of biomass-based cogeneration in Guyana and to facilitate the decision-making process for its application, the Commonwealth Science Council, London sponsored a workshop on *Biomass based cogeneration in Guyana* organized by TERI in Georgetown, Guyana during 3–5 June 1996. The workshop was formally inaugurated by the Prime Minister of Guyana, Honourable Mr Samuel Hinds, Member of Parliament Mr Narendra Kumar, the High Commissioner of India in Guyana, was also present on the occasion

The workshop covered several important issues related to cogeneration with an objective to formulate a national energy strategy for the promotion of biomass-based cogeneration and to address institutional, technical, financial, and legal issues A panel of participants from within the country including the management of Guyana Sugar Company (GUYSUCO) and the Guyana Electricity Corporation (GEC) participated in the workshop

Representatives from the Ministry of Finance, Government of Guyana, and several corporate sector representatives from the UK, Canada, India, and the US took active part in the discussions

The workshop focussed on the potential and economics of cogeneration, its benefits, international trends, its relevance to Guyana, and existing technologies, demand and supply issues in the power sector in Guyana, financial implications for producing surplus power for supply to the grid, institutional issues related to decentralized power generation, and grid-related problems. Technical issues like wheeling and third-party sales, and financial, economic, and legal aspects of the elements of a power purchase agreement were also covered.

The major issues identified included the preparation of a bankable power purchase agreement and fixation of cogenerated power tariff

As an outcome of the workshop, a task force on cogeneration was constituted to formulate a draft national programme for biomass-based cogeneration to supplement the national grid with surplus power The task force comprises representatives from several Guyanese government agencies, the private sector, the Commonwealth Science Council, and TERI. The task force convened during the workshop itself and identified issues and problems that may need to be addressed for the success of cogeneration in Guyana. It also identified decentralized sources of electrical energy, including biomass and other renewable energy sources, as feasible options and recommended two projects that should be implemented by the end of the first half of 1999.

The relevance and significance of this workshop in today's scenario cannot be ignored. Though concentrating on Guyana, the issues discussed and the resulting options identified would be applicable to other countries as well. Most Latin American and some tropical countries have substantial quantities of biomass, especially bagasse, which makes cogeneration particularly attractive Among the countries that have set up good projects using cogeneration are Brazil, the USA (Hawaii), Jamaica, and to some extent, Mexico.

Among Commonwealth countries, Mauritius provides an excellent example of a sugar producing nation that has successfully invested in and managed cogeneration projects using bagasse

The publication of these proceedings therefore would be useful in fostering South-South cooperation in a field of growing importance and relevance to several Commonwealth countries

Dr Ulric O'D Trotz
Director, Science and Technology Division
Secretary, Commonwealth Science Council

Preface

Guyana is abundant in natural resources and its location in the equatorial region provides it with adequate biomass The large number of sugar and rice mills, and a booming timber industry provide enough biomass to meet a substantial amount of the power and heat requirements within these sectors However, the adoption of advanced cogeneration technologies can generate substantial quantities of surplus power for export to the national grid by the efficient utilization of the biomass, generated in these sectors as waste.

The workshop focused on the potential for biomass-based cogeneration, addressing technical and non-technical barriers and the identification of cogeneration projects The workshop was well attended by all involved in the decision-making process—the Guyana Electricity Corporation, the Guyana Sugar Company, the Guyana Natural Resources Agency, and others from the various ministries There was also active participation from the private sector, particularly from the rice mill owners, timber industry, and the project developers

The Commonwealth Science Council, London, provided the support in terms of the financial sponsorship Dr Peter de Groot from the Commonwealth Science Council participated very actively in the workshop

Special mention must be made of Ms C V Indira and Mr Anil Verma for their editorial assistance, Mr T P Sankar for carrying out the editorial corrections, Ms Anshu Sharma for the design and layout, and Mr R K Joshi for graphic assistance

Editor

Background

Cogeneration in Guyana

The Cooperative Republic of Guyana is a country that suffers from acute shortage of electrical power It recognizes the need for rapid rates of investment in the power sector in the next five years to extend and improve power supply and to meet the needs of a growing economy Currently, major industries, including the mining sector, generate to meet their own power requirements

Guyana is blessed with extensive natural resources and has great potential in the agro-based industrial sector The sugar sector is large, possessing significant potential for commercial cogeneration of electrical power that can greatly alleviate the overall national energy situation Guyanese sugarcane has high fibre content that translates to large quantities of renewable by product fuel (bagasse) and a long grinding season that ensures greater availability of this fuel during the year for a cogeneration facility The sugar industry presently uses bagasse as boiler fuel inefficiently and in other industrial sectors for steam raising and electricity generation Nevertheless, bagasse is also one important source of energy contributing substantially to about 26% of the total energy input A more efficient use of bagasse and other biomass through commercial cogeneration will not only augment availability and stability of grid power supply, but also yield several other benefits including savings in foreign exchange for the country by fuel substitution for imported fuel oil, reduction of environmental pollution, creation of employment and generation of additional revenues for the sugar industry and the other agro-based industries like the timber industry and the rice mills.

The Government of Guyana (GOG), faced with rapidly growing energy requirements to support its economic development, needs to adopt both short and long-term measures to tackle the crisis One major way of meeting this requirement is to improve its existing energy efficiency and adopting energy efficient technology like cogeneration, which will cut production costs and reduce unnecessary consumption of energy This paper will discuss about the various cogeneration technologies, status of technologies available worldwide, and benefits of cogeneration and some traditional barriers related to costs, incentives, pricing, institutional, and a legal framework for the adoption of cogeneration.

Several industries such as sugar, rice mills, sawmills, food processing, etc , generate their steam requirements internally and purchase electricity from the grid Opting for cogeneration can enable them to produce both steam and electricity requirements internally thereby reducing the demand for electricity purchased from the utilities. In addition, surplus electricity, if any, can be sold to the utilities

Energy intensive industries like the aluminum industry also have enormous scope for cogeneration, by which they can produce both steam and electricity simultaneously. Electricity generated can be used to meet the internal electric requirements and thus reduce the requirement for utility power and additionally they could perhaps sell the surplus, if any, to the utilities. Co-

generation thus provides an alternative to the conventional utility power and reduces the overall emissions from the efficient use of fossil fuels.

Cogeneration from bagasse is well established and is practiced in several countries providing substantial power input to the national grid Successful examples are Hawaii, and the Reunion Island. Cogeneration is also practiced in various other industries such as pulp and paper, rayon, sugar, chemicals, and fertilizers. Although cogeneration is beneficial in many ways, industries are compelled to continue with non-optimal systems for reasons such as company investment criteria, availability of equipment, incremental costs and reliability, and above all, government regulations

Guyana Electricity Corporation

Guyana Electricity Corporation (GEC) supplies electric power in Guyana, another public sector company, which generates most of its electricity through nine plants and manages the grid. GEC is presently under a management contract with an Inter-American Development Bank (IDB) consultant Although the total installed capacity of GEC is 75 MW, only about 37 MW is available to the grid because of poor equipment and management. GEC's tariff revenues are low because the present average tariff is lower than the generating cost and because of inadequate metering and collection methods. Neither GEC nor the Government has the financial resources to overhaul the power sector

The present Government is aware of the problems of the power sector and is taking several steps to improve the situation. In the Government's strategy for this sector, cogeneration in the sugar industry is being considered as an option to provide a reserve supply of 20–30 MW to the grid in the medium term They have commissioned and completed several feasibility studies including a detailed project report by F C Schaffer & Associates, Louisiana (FCS&A), USA The FCS&A study estimates that the sugar industry has a total cogeneration potential of 100 MW of which 50–60 MW is currently financially attractive Also, a study conducted by Centre for Environment and Development in Crabwood Creek shows that 1 5 MW of electricity from woodwaste generation is possible

Considering the significance of bagasse-based cogeneration in Guyana and to help the decision-making process for its application, Tata Energy Research Institute (TERI), as an objective third-party, has prepared this paper for the three-day workshop in Guyana with the following objectives·

- to facilitate discussion and resolution of the critical issues impeding the use of cogeneration in the sugar and other agro-based industries by bringing together all concerned parties to the forum, and
- to evolve a consensus plan of action and strategy for the application of cogeneration based on the involvement and approval of key decision-makers from the Government, Guyana Sugar Company (GUYSUCO), GEC, and financial institutions

For maximum effectiveness, participation in this workshop should ensure adequate coverage of all relevant issues and involvement of key decision-makers. An appropriate panel of in-country

participants will include the management of GUYSUCO, GEC, and TERI in consultation with the government of Guyana In addition, TERI will identify and invite international experts to address technical and financial issues TERI, in collaboration with a designated Guyanese agency and consultation with the participants, will develop relevant background materials for circulation before the workshop

- National energy strategy and the importance and role of cogenerators in providing power to the national grid
- Operational and strategic challenges faced by the management of GUYSUCO and GEC in starting cogeneration and adapting to Guyana's economic recovery and growth
- Institutional issues including the organization, management and operation of cogeneration plants, institutional linkages with GUYSUCO and GEC for bagasse/biomass and power sales respectively
- Technical concerns such as type of plant, equipment specification and sourcing, training of personnel for operating cogeneration equipment
- Financing issues such as sources of credit and guarantee cover for cogeneration projects
- Fiscal and legal issues such as the provision of tax concessions and other incentives by the Government, and the establishment of a legal framework for the sale of cogenerated electricity to GEC

Based on the discussion and ideas of parties on these issues, they will evolve a draft plan of action for cogeneration The second day of the workshop will be used for a more confined meeting of the important decision-makers from the Government, GUYSUCO, GEC, and the financial institution(s) to refine the plan of action, elicit consensus and support, and prepare a strategy for carrying out the plan of action

Current energy scene in Guyana

Guyana's energy policy, prepared by the National Energy Policy Committee (1994), prepared the strategy paper after reviewing the energy consumption pattern over a period of four years (1988–1992) The committee composed of technicians from key agencies in the energy sector in Guyana, which are responsible for energy research, petroleum exploration and development; preparation, implementation, and management of energy projects and programmes, electricity generation; transmission and distribution; and energy conservation

The Energy Policy Committee reviewed the energy situation for the period 1988–1992 that provided relevant data on energy and the economy of the country. The committee also provided future directions for the period 1994–2004

Between 1988 and 1992, final energy consumption increased by 3.2% whereas per capita energy consumption increased by approximately 3 0% During this period, petroleum products, bagasse and fuelwood were the major fuel sources They also identified major energy consuming sectors namely electricity generation, industry, mining, transportation, and the residential sectors. The quantum of various fuels consumed in the year 1992 in the various sectors of the economy is shown in the Table 1.

Table 1. Energy supply and sectoral use—1992 (10^3 boe)

Sector	Bagasse	Fuelwood	Petroleum Products	Total	% of total supply
Electricity generation	400 0	40 0	1069 0	1509 0	24 5
Charcoal production	NA	13 0	NA	13 0	0 2
Transportation	NA	NA	593 0	593 0	9 6
Industry and mining	1196 0	65 0	880 0	2141 0	34 8
Residential	NA	1444 0	140 0	1584 0	25 7
Commercial and public	NA	NA	18 0	18 0	0 4
Agriculture and fishing	NA	NA	296 0	296 0	4 8
Total	1596 0	1562 0	2996 0	6154 0	100 0

Source GNEA Records
NA· Figures exclude OMAE and illegal importation of petroleum products (figures rounded)

Guyana imported petroleum products of the value of US $63 53 million in 1988, which was equivalent to 3 364 000 barrels, and in the year 1992 the corresponding figures were US $61 47 million and 2 691 000 barrels

The indigenous energy resources that contributed significantly to the energy supply were bagasse (for co-generation in the sugar industry) and fuelwood (for the residential sector) Other resources (hydropower, woodwaste, rice-husk, wind, solar) while available, did not contribute significantly to the energy supply

The details of the different fuels consumed during the period 1988–92 are given in Table 2

The supply of petroleum products decreased from 3 252 000 barrels of oil equivalent (boe) to 2 996 000 boe for the period 1988–1992, a decline of 7 9% They attributed this decline to the dramatic reduction in the production of bauxite. They attributed the decline in the consumption of motor gasoline to the increased availability of mini-buses The decontrol of the gasoline prices and the devaluation of the Guyana dollar also led to more rational use of petroleum products

Bagasse supply increased from 980 000 boe in 1988 to 1 596 000 boe in 1992 Fuelwood supply, also increased marginally by 1 2% between 1988 and 1992 However, during this period, as a percentage of total energy supply, fuelwood decreased by approximately two per cent

Table 2 Energy supply by source—1988–1992

Energy source	1988		1992	
	10^3 boe	% of total	10^3 boe	% of total
Petroleum products	3252	56	2996	49
Bagasse	980	17	1596	26
Fuelwood*	1543	27	1562	25
Total	5775	100	6154	100

* OLADE estimates
Source GNEA Records

Economic growth and final energy consumption

During the period 1988–1992, Gross Domestic Product (GDP) at constant factor cost (1988 prices) and total final energy consumption had an increasing trend The GDP increased from G $3 6 billion in 1988 to G $3 792 billion in 1992, reflecting an increase of 5 3% In 1988, the total final energy consumption was 4 713 000 boe and in 1992, it was 4 864 000 boe This represented an increase of 3.2% The per capita energy consumption increased during the period 1988–1992 from 6 2 boe to 6 4 boe.

The electricity industry

GEC, a public sector company, is responsible for the national grid GEC generates most of its own electricity in nine generating plants, though it does purchase a small quantity of energy from a bauxite mining company A private consortium recently agreed to generate additional power for sale to the Corporation Commercial enterprises for their own use carry out a significant amount of captive power generation due to the lack of dependable power from GEC.

GEC has two main power systems interconnected, and three isolated ones The interconnection between the two main electric grids is in need of upgrading and this upgrading is in GEC's present plans Total installed capacity is about 75 MW, with some plants in disrepair. Maximum power available to the grid at any one time varies from 23 to 35 MW This is sorely inadequate for present needs, and electric power represents one of the most critical constraints on the pace at which the Guyanese economy can move forward in response to other favourable factors What power is available is not dependable, and is expensive since they generate much of it in relatively small diesel units The present GEC tariff income averages about US $0 10/kWh generated, while generating costs are about US $0 15/kWh Part of the low GEC tariff revenues is due to inadequate metering and collection methods, however, continuing improvements in this area are considerable and are progressing

The percentage total energy use increased in the electricity sector from 21.2 % to 24.5 % from 1988 to 1992 Petroleum products represented 80% and bagasse 20% of resources used to generate electricity in 1988 By 1992, these figures changed to 70 8% and 26 5%, respectively

In the electricity sector, petroleum products have been the major source of energy (70%–80%). During this period there was approximately 10% decrease in the use of petroleum products and increased bagasse use of 64% It must be noted that increased use of bagasse was mainly due to inefficient utilization of this energy source

Domestic energy resources

The only fossil fuel occurring in Guyana is petroleum. However, the Guyanese have not yet quantified these resources and there is no commercial exploitation at this time

They estimate that economic potential was in the region of 7000 MW. The Guyanese are not exploiting this resource currently but the solution to the country's long-term power needs lies in hydro energy

Forests cover approximately 75% or 16 million hectares of the country's land area However, active encouragement of increased fuelwood consumption would have to be reduced due to environmental concerns. Instead, woodwaste from the timber industry remains a viable potential source of energy. Currently, two lumber enterprises generate a total of 3 MW of power from woodwaste for their industrial uses.

Currently bagasse is used, most of it inefficiently, for the cogeneration of steam and electricity in the sugar industry They have carried out an analysis of the true potential of this energy source and they are attempting to maximize the benefits.

Rice husk is also a viable potential source of energy and is currently used by two rice millers for steam and electricity generation (approximately 1 MW) This resource needs to be developed further

Biogas digesters provide methane gas for cooking and refrigeration In the residential sector, the impact is more social and environmental rather than economic The cost of construction of these digesters must be reduced considerably for any major economic impact in the residential sectors. For large commercial and agricultural enterprises, this technology can be cost-effective

Future energy requirements

The following tables show the future energy requirements for the years 1998–2004 (Table 3 and 4)

Biomass

Bagasse

Studies have shown that there is sufficient bagasse at the Albion and LBI sugar estates to generate 20 MW and 10 MW of electricity, respectively. They should undertake the development of this source of energy, through the installation of generating plants at Albion and LBI to supply electricity to the national grid.

Table 3 Energy supply and sectoral use (1998)

Sector	Bagasse	Fuelwood	Rice husk	Petroleum products	Total	% of total supply
Electricity generation	475	95	95	811	1476	23 7
Charcoal production	NA	13	NA	NA	13	0 2
Transportation	NA	NA	NA	652	652	10 5
Industry and mining	1121	65	NA	1000	2186	35 1
Residential	NA	1444	NA	146	1590	25 5
Commercial and public	NA	NA	NA	13	13	0 2
Agriculture and fishing	NA	NA	NA	296	296	4 8
Total	1671	1671	95	2918	6226	100

NA Not applicable

Table 4 Energy supply and sectoral use (2004)

Sector	Bagasse	Fuelwood	Rice husk	Hydro	Petroleum products	Total	% of total supply
Electricity generation	378	NA	NA	420	62	860	14 9
Charcoal production	NA	13	NA	NA	NA	13	0 1
Transportation	NA	NA.	NA	NA	694	694	12 1
Industry and mining	1218	65	NA	NA	1000	2283	40 0
Residential	NA	1444	NA	NA	152	1596	27 7
Commercial and public	NA	NA	NA	NA	13	13	0 1
Agriculture and fishing	NA	NA	NA	NA	296	296	5 1
Total	1576	1522	NA	420	2217	5755	100

NA Not applicable

Woodwaste

Two private companies currently use woodwaste to generate approximately 1.5 MW of power for their operations They should take immediate steps to encourage use of woodwaste in concentrated sawmilling areas, e.g , Crabwood Creek and for large operations like Demerara Timbers Limited (DTL), Barama for power generation This power could be used in industrial applications with the excess to be supplied to the national grid. The isolated sawmills can establish systems for self-utilization and the surrounding communities can use any excess

Fuelwood

The statistics show that fuelwood is used widely for domestic purposes However, they do not organize the supply of fuelwood nationally Producing heat energy, from the energy source, generates significant savings through substitution for electricity, kerosene, and liquefied petroleum gas (LPG) Therefore, they should try towards the development of an organized fuelwood industry to satisfy the national demand of this energy source, in an environmentally friendly manner, with particular attention to the rural communities

Rice husk

Two companies are currently using rice husk for power generation and for processing. They have evaluated the available potential, and they should try to establish central generating plants in areas where there is a high concentration of mills They must envisage both cases—industrial and domestic

Biogas (from animal waste, vegetable matter, distillery waste)

There are about 85 biogas digesters that they built since 1985 in the country, with volumes varying in sizes from 81 216 to 20 cu m. They have identified biogas technology as part of the solution to the energy problem in Guyana. However, more education, cheaper design costs, and proper surveys need to be conducted to ensure that they widely use the technology among farmers for cooking, lighting, and refrigeration.

Strategies for satisfying energy demand

The National Energy Policy Committee enumerated the following points to meet the country's energy requirements up to 2004

- more efficient use of bagasse to supply power to the national grid,
- increased use of woodwaste and rice-husk for electricity generation,
- development of major hydro power facilities,
- more efficient use of petroleum-based products and energy generally through conservation measures,
- provision of fiscal incentives and appropriate legislation to support energy development programmes,
- establishing energy farms to provide fuelwood source for household uses,
- continuation of oil exploration activities, and
- development of small mini/micro hydro power, solar and wind technologies for remote and isolated communities.

Concept of cogeneration

Cogeneration is the efficient production of two forms of useful energy from the same fuel resource, using the exhaust energy from one production system as the input for the other Ordinarily, the primary energy form is thermal (steam) and the secondary form is either electrical or mechanical. The electrical or mechanical energy can be used internally to run company equipment and thus reduce the demand for utility power, and the surplus electricity, if available, can be sold to the utilities. Such a system can reduce energy input to 10–30% of what separate systems require to produce the same outputs Total system efficiency can approach 90%, a significant improvement over the 50–90% efficiency of many industrial boilers and 30–35% efficiency of electrical conversion when separate production is used As a result, this simultaneous efficient production of two energy forms can significantly reduce total operating costs in many instances, even after paying for the increased capital costs

Cogeneration system types

By-product power generation (topping turbines)

In steam turbine systems, by-product power generation implies that power is generated by non-condensing turbine sections, either an extraction section or a non-condensing exhaust section Both cases would generally be operated in a pressure-governing mode That is, the turbine inlet valves and the extraction valves would be regulated in order to maintain constant exhaust and extraction pressure The amount of power generated would depend on the process steam demands and, therefore, is a by-product of supplying the process heat To meet the total electric power demand, another source of power generation or a utility tie would be required

Most non-condensing steam turbines which operate on pressure governing are synchronized with the other sources of power. The turbine-generator speed is locked into the system frequency, and therefore, speed is not a controlled variable during normal operation Steam turbine by-product power generation is sometimes called topping-turbine power generation.

Any heat engine, such as gas turbine or diesel, which supplies useful exhaust heat is considered to generate by-product power The power need not be electricity Heat engines that drive pumps or compressors can generate by-product power directly, though it would be measured in horsepower instead of kilowatts

Finally, there can be exceptions to the relationship between by-product power and non-condensing steam-turbine power generation Occasionally, when more electrical power is required than is available from existing sources in a particular industrial plant, additional steam can be expanded through a non-condensing steam-turbine section or recovered in a separate heat exchanger which condenses the steam (a dump condenser) This steam does not provide any useful heat and is not considered to generate by-product power This mode of operation is normally limited to transient conditions as it is a very inefficient use of energy

Condensing power

Automatic-extraction condensing steam turbines have the capability to supply process steam at a controlled pressure and to independently control the amount of electric power generated by the condensing section Power generated by the steam which is extracted to the process is by-product power However, the power generated by steam expanding to the condenser is not It is simply called condensing power Of course, if the condensing steam turbine had no extraction, it would provide electric power only and no useful heat It would then not qualify as a cogeneration system

A great deal of energy is lost in the condenser to the cooling water in condensing power generation Hence, the fuel is not used as effectively as in by-product power generation Nevertheless, many cogeneration steam turbine systems do include some condensing power. Some reasons for including the condensing section are

- no external power is available from a utility,
- the energy in the steam is available at low cost, either from a by-product or waste fuel, or process-waste-heat recovery,
- condensing power may be economic to shave peak electric demands and, therefore, reduce demand charges paid to the utility,
- when the industrial plant has several steam turbine-generators, normal operation would have a minimum amount of condensing power, but the condensing end can be used to full capacity as reserve during a shutdown of another generator,
- when the industrial plant has several steam turbine-generators, a condensing section on one unit can simplify dispatching of power among the units, and
- in joint utility/ industrial cogeneration schemes, the condensing power is another source of generation that can be dispatched as the economics of the system demand

There is also an exception to the definition of condensing power. Some industrial process heating systems have the requirement to heat large quantities of cold water. Using it as cooling can preheat this water in the turbine condenser Therefore, the steam expanded to the condenser also provides useful heat and is considered by-product power However, this type of application is not typical as the quantity of water to be heated, usually, is a small fraction of the condenser cooling-water flow

Bottoming cycles

A bottoming cycle is generally considered one that uses waste heat from another source to generate power. Some waste heat sources are given below

- Gas turbine exhaust gas
- Fired process-heater exhaust gas
- Process streams that require cooling

Exhaust of a gas turbine at 400–600 °C is used to generate turbine inlet steam by a heat-recovery steam generator (HRSG) The process furnace stack can also be used to generate steam In some processes, such as ethylene and ammonia, process streams are heated to 800 °C, in a furnace and are then cooled or quenched This heat can also be used to generate turbine inlet steam

It should be noted that by-product or topping-turbine cycles and bottoming cycles are not mutually exclusive That is, a non-condensing steam turbine-generator can bottom one process heat source and while top a lower temperature heat requirement A bottoming cycle can also be a straight condensing steam turbine or an automatic-extraction condensing steam turbine

The process-heat recovery might also be used from a flue gas of only 300–500 °C This is too low to generate turbine inlet steam here, but adequate for generating 10 bar process steam When the heat-recovery steam generation exceeds the process requirement, the excess steam can be admitted to the turbine-generator. Extraction–admission is another feature which can be specified for cogeneration steam turbines

Power generation cycles which rely on by-product fuels are similar to bottoming cycles Some fuel sources are listed below

- forest product industries (pulp, paper, plywood, sawmills) wood waste, sawdust, bark, and black-liquor recovery boilers,
- petroleum and chemical industries residual hydrocarbons, off gases,
- basic steel making—coke oven gas, blast furnace gas, BOP off gases,
- food processing—fibrous wastes such as bagasse in sugar refining, and
- refuse disposal plants (trash)

Most industrial plants which cogenerate encompasses several system types For example, bottoming cycles rarely exist in their purest form. Some fossil fuel steam generating capacity in order generally supplements them to independently controlled steam production Many industrial powerhouses include automatic-extraction condensing steam turbine-generators supplied by waste heat or by-product fuel boilers and fossil fuel boilers Therefore, a unit often represents a bottoming cycle, by-product power generation or a topping cycle, condensing power cycle, and by-product fuel cycle

Energy conservation potential in cogeneration systems

The potential for conserving fuel through cogeneration depends on the users' demand for electricity and heat, and on the type of cogeneration system to be used Steam turbine, combustion

turbine, and diesel engine systems will each produce a different ratio of electricity to heat output. Fuel conservation will depend on a cogeneration system's ability to match the user's overall needs for each type of energy output and to cope with fluctuations in the individual demands. Steam is the primary form in which the heat output from a cogeneration system can be utilized. Steam is widely used in industry, and to a somewhat lesser extent in buildings, to transport heat to a point of use Almost one half of all the industrial fuel burned is consumed in generating versatile, easy-to-use steam A large, well-designed, industrial boiler will convert 85–90% of the combustion heat of the fuel into steam If this steam is used for heating, and if, after such use, the hot condensate water is returned to the boiler, almost all of the heat content of the steam can be effectively used. However, when steam is employed to generate electricity in a modern, high-pressure, high-temperature, single purpose plant, only 37–40% of the fuel's combustion heat is converted to electricity Most of the remaining heat is lost through condensers at the end of the electricity generating process, amounting to 60–63%. While rejecting this large (45–48%) proportion of a fuel's heat energy seems inefficient, the electricity produced is 'high quality' energy with the capacity to do more work or generate higher temperature than could be obtained from the rejected low pressure steam

While cogeneration systems improve the overall efficiency of fuel use, some gain is at the expense of electrical power generation When steam is discharged from a turbine at pressures high enough for heating uses, electrical power output is reduced proportionately In a cogeneration system producing by-product steam at a useful pressure of 50 psi, only about 15% of the input energy will come out as electricity, and almost 70% will be in the steam

Cogeneration systems based on diesel engines or combustion turbines can produce higher electricity to steam ratios. However, the ratio for a given system is relatively constant and must match the needs of the installation or it will restrict the energy conservation potential If the actual demand ratio varies more than a few percent from the design (expected) ratio for the system, discarding will usually be necessary and waste the excess energy output

Cogeneration systems may encounter highly variable demands for electricity and steam when serving end uses such as mechanical work, electrical lighting, or heating An industrial plant may have a peak steam or electricity demand during a particular shift each day Consequently, demand for electricity may not coincide with a corresponding demand for the cogenerated heat. A useful, fuel-conserving cogeneration system must be able to produce electricity and heat (e.g., steam) in proportions to match the 'load' or array of uses served whenever required In contrast, a prime attraction of conventional, single-purpose systems for process steam, space heating, or electricity generation is that the fuel input and the operating characteristics of the system are controlled by only one output demand.

Different modes of cogeneration will vary in their output ratio of electricity, high-temperature, and low temperature heat. A basic steam turbine cogeneration system produces only about 15% of electricity with 70% of the heat energy in exhaust steam. A combined cycle cogeneration system using a combustion turbine and an exhaust-heat boiler produces 30% of electricity with 47% of input heat in exhaust steam. A diesel cogeneration system using an exhaust-heat boiler produces 36% of electricity with 27% of heat in the exhaust steam

These ratios of electricity to steam are based on a steam pressure of three bars, which is somewhat low for average industrial use For the higher pressures required in many steam systems, the

electricity to steam ratios will be lower for steam turbine cogeneration, but higher for the combustion turbine or diesel engine modes. However, in any system designed for higher electricity/steam ratios, the fuel consumption per unit of electricity also increases and the energy conservation potential is diminished The overall efficiency of fuel use in a cogeneration system will, therefore, depend upon the type of system installed and the user requirements for electricity and high or low-pressure steam from the system.

Cogeneration is currently favored where an industrial plant can satisfy its needs for electricity and steam with a simple, basic boiler and steam turbine system. Such plants will use 65–80% of their energy demand as a low pressure (about 10 bars) steam, and the remaining 20–35% as electricity For example, these conditions are found in many paper plants, and the pulp and paper industry is a leader in industrial cogeneration. Approximately 30% of the electricity used in the pulp and paper industry is cogenerated with the steam production in paper mills Another area in which cogeneration has been actively employed and also integrated into the system are the fertilizer industries. Most the energy requirements of the Ammonia and the Urea plants are met by the steam generated through high pressure waste-heat boilers.

Overall, industrial cogeneration systems are designed primarily to satisfy the heating requirements of an installation, and electricity is considered only a by-product This electricity might be sold to the local utility grid or used internally. In either case, it replaces electricity conventionally generated in single-purpose power plants Cogenerated electricity, depending on the system used, is produced with only 40–70% of the fuel normally required in an efficient, single-purpose power plant

The potential for fuel conservation thus depends upon how much by-product electricity can be cogenerated, which in turn depends upon both the steam and hot water heating demand of the user and the mode of cogeneration employed For a given heating-energy output requirement, steam turbine cogeneration will yield by-product electricity with a maximum fuel saving equivalent to 30% of the energy in the steam output In combustion turbine and diesel engine systems, the overall fuel savings can be equivalent to 70% and 85% of the respective steam-energy output However, because these latter two modes produce such high ratios of electricity to steam, the fuel saving per unit of electricity generated is actually less than for the steam turbine mode.

The overall potential for fuel conservation using cogeneration depends upon the relationship between the size and characteristics of user demands for low-temperature heat and for electricity and the mode of cogeneration employed It is unlikely that cogeneration systems that fulfill the operating and economic requirements of an individual user will also produce maximum oil and gas savings from a national view point A user with a high electricity/low steam demand will not be well served by a cogeneration system with a low electricity/steam production ratio, even if that system provides fuel-cheap electricity Though electricity production can "ride" industrial process steam production, making dual use of fuel, either the electricity or the steam cogenerated may not be available in the amount or at the time that it is needed This conflict is but one factor hampering realization of the full conservation benefits from cogeneration.

Constraints for promoting cogeneration

While conservation potential through total energy systems has been well appreciated, as also the many advantages one would derive from the concept, there are several barriers to cogeneration which restrict the adoption of such systems by the industries The following is a list of identified cogeneration market barriers which may be applicable to Guyana

Regulatory considerations

The key regulations that qualify and regulate cogenerators are relatively new and are still being considered by the utility industry. The GEC currently has no regulations concerning cogeneration. Changes in GOG policy concerning other investment incentives, tariff, banking and wheeling facilities, can greatly affect the market

The Electric Lighting Act states that the President may license any local authorities, companies or persons to supply electricity for public or private purposes within any area. Under this Act, it would, for example, be possible for the President to allow the power plant company to supply electricity to GEC

The Electricity Act established GEC, which states that it has the exclusive right to sell energy in the areas prescribed by the Act. They explicitly define the areas in the Act. The Act states that the Minister can from time to time alter the boundaries of the franchise or "add to or exclude from such areas any area specified".

Interconnection contracts such as the one being contemplated between the projected company and GEC must be presented for approval to the Ministry of Public Utilities, which submits these to the Cabinet for final approval

A new national energy policy initiated in 1993 by GOG has caused favourable changes to allow private power projects and the President has expressed support for bagasse-based cogeneration projects

Utility buy-back rates

Electric utility buy-back rates are negotiated for each cogeneration site and are determined by the utility's avoided costs at that point in time As the structure of the utility industry changes and as more cogeneration capacity is brought on line, these buy-back rates may decrease and therefore discourage further cogeneration A more detailed discussion on pricing of cogenerated power is dealt with in this paper

A reluctance to enter the "power business"

Most manufacturing concerns have become accustomed to simply purchasing power and generating steam or process heat on-site. The prospect of adding a cogeneration system represents a large capital investment in what is usually an unfamiliar technology.

Electric utility resistance

Many electric utilities have adequate or excessive capacity at off-peak periods during the nights therefore, have little incentive to purchase electrical power from a cogenerator. Other utilities disagree with the distributed onsite power concept, having grown up during a period when large central stations dominated the utility structure.

Lack of cogeneration expertise

Most industrial concerns do not have in-house personnel capable of evaluating, operating or maintaining cogeneration systems In general, cogeneration technology expertise has been confined to specific industries that have traditionally used equipment of this type Training in operation and maintenance of high pressure boilers and steam turbines will be provided to ensure smooth operation of the cogeneration plant.

Limited capital resources

Many industrial concerns do not have sufficient internally generated funds, or are unwilling or unable to obtain external funds. The financial situation of the rice mills, saw mills in Guyana are currently not available However, GUYSUCO is still recovering from the financial losses incurred during the drought in the past years. The GOG has taken steps in the direction by inviting foreign project developers to install cogeneration plants

Higher priority of production-oriented projects

Cogeneration projects are oriented towards energy savings, and therefore, take a lower priority than production oriented projects Higher returns on investment are typically required with energy-saving projects when competing for limited capital budgets with production projects GUYSUCO is currently investing in modernizing and enhancing its production capacity The current position of the other agro-based industries is not known

Sensitivity to energy prices

Small variations in the input and output utility costs of a cogeneration unit could easily destroy the economics of the project

Possible plant closings

Companies will limit the scope of capital investment targeted at plants that may be severely curtailed or closed because of changing business or economic climates Cogeneration projects typically require years of steady operation to be economically viable, and therefore, are of limited interest in this situation This risk is not applicable in the case of GUYSUCO as sugarcane is one of their main crops. However, in the study conducted by the National Energy Policy Committee in the year 1994, showed decreased availability of fuelwood and rice husk in future The reasons for the non-availability are however, not known

High capital cost for cogeneration systems

The available prime mover technologies limit the potential sizes of cogeneration systems to relatively large and expensive units The high initial capital cost of cogeneration systems is a barrier in industries with limited financial strength

Proper size and thermal to electric output match

Accommodating the application's energy stream requirements with that available from the various technologies is instrumental to a successful project. Most cogeneration technologies have relatively fixed thermal to electric outputs and most applications have daily and/ or seasonal variations in utility requirements.

Adequate water supply

Many cogeneration technologies utilize heat recovery boilers that require a steady supply of high quality feedwater

Technological aspects

Cogeneration under the power maximization mode requires high pressure and high temperature system parameters. High pressure boilers, turbines and accessories will be imported. There is also a considerable technological gap between the various advanced configurations and systems available in the developed countries. There is a need to identify areas of research and development in the various cogeneration technologies required

Figure 1a and Figure 1b show the two technologies commonly used for cogeneration in sugar mills. The low pressure system which uses boilers at 17 bar and 260 °C will generate 5 MW power With the high pressure system, which operates at 48 bar and 400 °C will generate 12 MW power consuming slightly higher quantity of bagasse Most of the boilers which burn bagasse are usually multi-fuelled boilers and can also handle most biomass fuels. Therefore having a multi-fuelled boiler power plant located near the sugar mill and within a region where there several rice mills, and saw mills can make a great difference to the economics of the power project. A detailed study will be required to look into the economics of a centralized cogeneration plant placed say in Crabwood Creek, which can meet the energy requirements of all the industries and supply surplus firm power to the grid all year round

Technical evaluation of advanced combined gas turbine/steam turbine processes fueled with bagasse or biomass

Overview of process options

Even though some increase in electric power output can be obtained in old sugar mills by use of more technically advanced steam specifications, maximum utilization of the residual fuels requires employment of the combined gas turbine/steam turbine process.

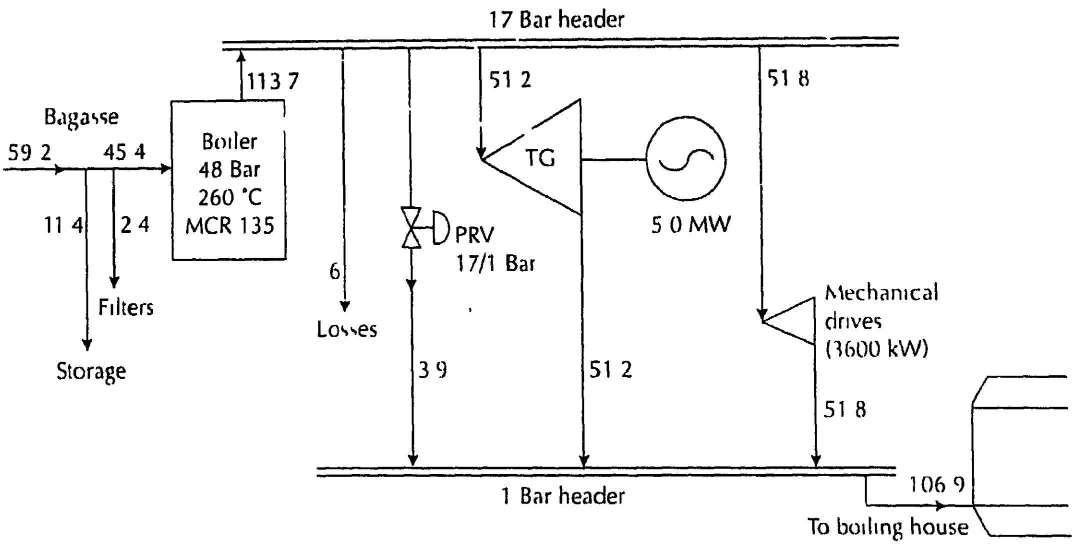


Figure 1a Low steam pressure and temperature, back-pressure generator

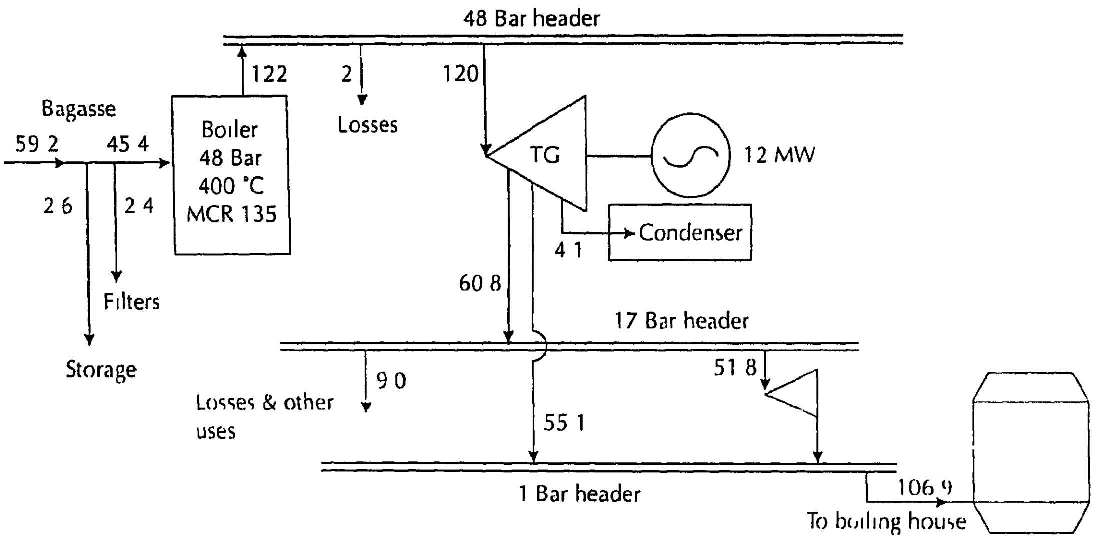


Figure 1b High steam pressure and temperature extraction-condensing turbogenerator

If the residual fuel is also used for the gas turbine, four options can be considered

- hot air turbine with external firing;
- integrated, pressurized gasifier supplying combustible gas to the gas turbine combustor,
- integrated atmosphere gasifier supplying combustible gas to be pressurized by a compressor and supplied to the gas turbine combustor; and
- direct use of the residual fuel in a modified pressurized combustor

These options are illustrated in Figure 2 None of the these processes are presently used in a commercial installation A problem is to find a way to stop mineral matter in a solid fuel from

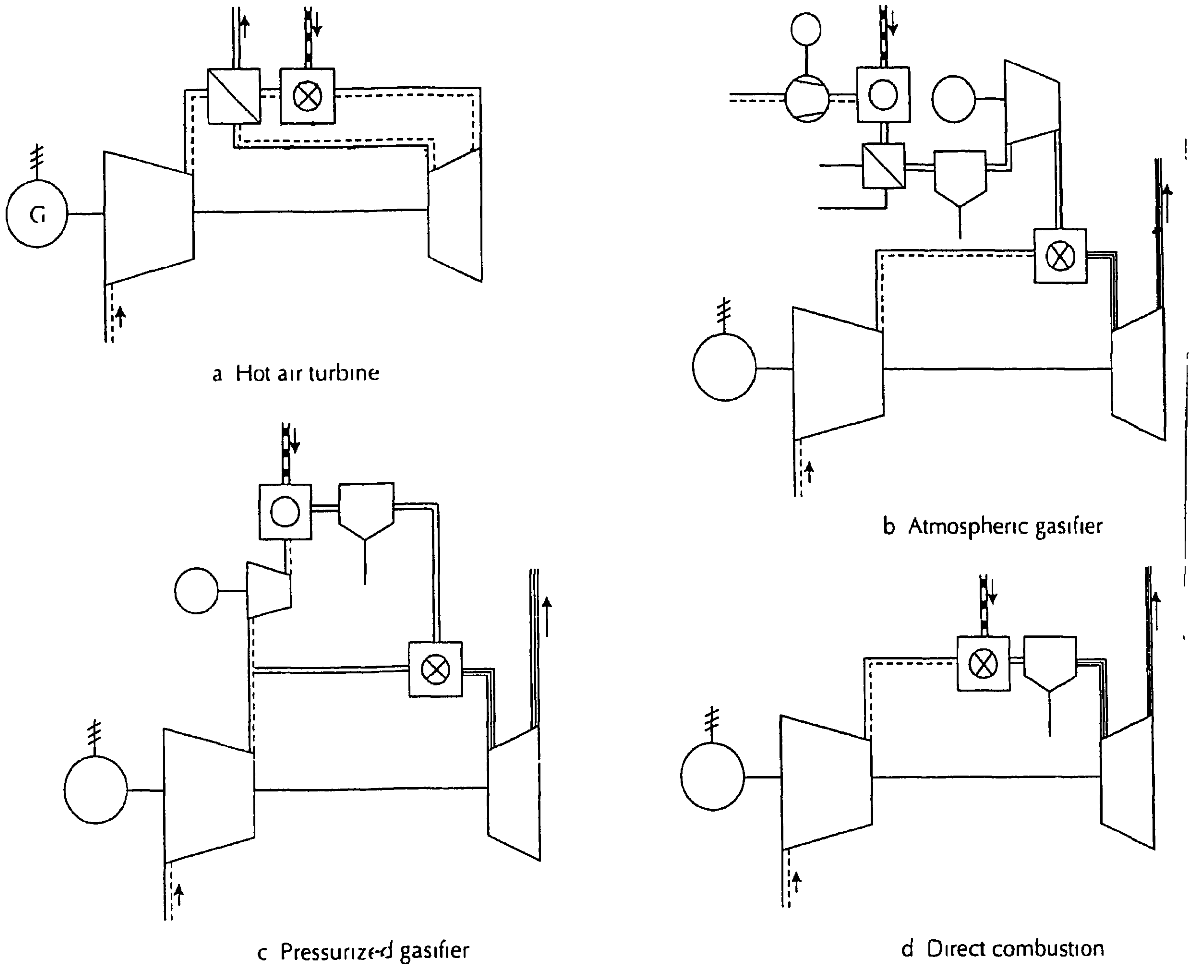


Figure 2 Options for using solid fuels to run a gas turbine

causing erosion, deposits, and corrosion in the gas turbine Gas turbines are designed to run on very clean fuels like natural gas or light petroleum fuels Solid fuels have relatively high ash contents which can lead to a gas with a high dust content. Some elements in the ash in particular sodium (Na), Potassium (K), and Vanadium (Va), form corrosive compounds with low melting points which may deposit in the turbine and cause corrosion. The problem can be eliminated by external firing A high efficiency process with a high inlet temperature to the gas turbine, however, requires an expensive heat exchanger made out of temperature resistant material

The gasification process generally includes cooling and filtering of the gas before combustion. This presents the possibility of reducing the amounts of dust and corrosive compounds but leads to some efficiency loss and investment in a gas filter

The direct combustion process is designed to limit the inlet temperature to the gas turbine to what can be used without corrosion and deposition problems when a simple cyclone is used for the gas cleaning Part of the trick is to choose the combustion temperature so that the

content of corrosive compounds in the gas is minimized. The limited gas turbine inlet temperature leads to a process with limited efficiency. The process is, however, much simpler and can therefore be expected to require the lowest investment. All the processes are currently subject to research and development. The current status of the work is summarized in the following Sections.

Externally fired gas turbines

In this cycle, the hot gases leaving the atmospheric pressure combustor are used to heat compressed air in a high temperature heat exchanger The air expands through the turbine and is used as combustion air in the combustor for solid fuel. The gases leaving the heat exchanger can be used to produce steam in a HRSG

The turbine for this type of cycle can be expected to be long lasting, since only clean air is passed through the turbine The major disadvantage of the indirectly fired gas turbine system is higher capital investment than for directly fired systems because of the large expensive heat exchanger.

The first gas turbine power plant of this type was commissioned in Switzerland during the 1930s. Five units for cogeneration of electric power and heat were built in Germany. Only one was still in operation in 1987 The installations used a closed loop. The last one built had a minimum system pressure of 10 bar. The electric power output ranged from 2 3 MW in Ravensburg to 17 3 MW in Gelsenkirchen The turbine inlet temperature ranged from 660 °C to 711 °C giving electric efficiencies, respectively, of between 26% and 31% when exhaust air from the turbine was used to pre-heat the air after the compressor. The heat exchangers transferring heat from the combustion gases were made of authentic steel. The operating experiences were excellent When closed down for economic reasons, the plants had accumulated each between 120 000 and 160 000 operating hours

Research focused on development of this process is presently going on in the USA The research aims at development of a ceramic heat exchanger which allows operation with a gas turbine inlet temperature of about 1200 °C Tests with heat exchanger tubes were conducted between 1988 and 1992. A 2 MW test facility using coal fuel has been built in Kennebunk, Maine, USA A conceptual plant using a 43 MW gas turbine GE LM6000 and a 44 MW steam turbine is expected to require an investment of 1740 USD/kW and have a net efficiency with coal as fuel of 39 8% There are plans for using this process for re-powering of an old steam power plant, giving a total output of 84 MW, of which 41 MW is from the gas turbine This plant is expected to start operation in 1996. There is no reason to expect that the plant would not be able to operate on biomass fuel if it can operate on coal.

The most promising combustion technology for heating compressed air is the atmospheric fluidized bed combustor (AFBC) used as an air heater This technology is well established for steam generation using biomass fuels, but no commercial AFBC air heater installation exists

Integrated atmospheric gasifier

Gasification of solid fuels by means of partial combustion with air is an old technology which was in widespread use during the first half of this century. The low cost of natural gas and petro-

leum fuels after the second World War made the technology less attractive In the late 1970s, the increase in petroleum prices resulted in renewed interest

For gasification of sugarcane residue for operation of a gas turbine in combined cycle at a sugar mill, only gasifiers based on either counter-current flow in a fixed bed or the fluidized bed technology can be considered Co-current fixed bed gasifiers are not suitable for feedstocks with the low bulk density associated with bagasse and shredded cane trash. The maximum capacity of fixed bed counter-current gasifiers is about 10 MW (fuel), whereas fluidized bed gasifiers can be designed for at least 5 times as large capacities.

Both types of gasifiers are being operated in Sweden using wood residue as fuel and providing fuel gas to furnaces for process heat generation There seems to be no documented experiences from use of bagasse or cane trash as feedstock for these gasifier types

The scheme for integrating an atmospheric gasifier with a combined gas turbine/steam turbine process is illustrated in Figure 3 This is the process suggested by the Swedish company TPS for the Global Environment Facility project in Brazil A plant based on the same process, using short-rotation plantation wood as fuel was recently sold by TPS to a utility in Great Britain.

Drying is required in order to meet the fuel gas calorific value requirements of the gas turbine Drying is normally recommended down to 10–20% moisture The gas exhaust stream from the dryer is cleaned of dust particles prior to the dryer stack

The gasification system offered by TPS consists of a cylindrical, refractory lined steel vessel. At the bottom of the vessel there is an ash drain Above the ash drain, there is a fluidized bed blown

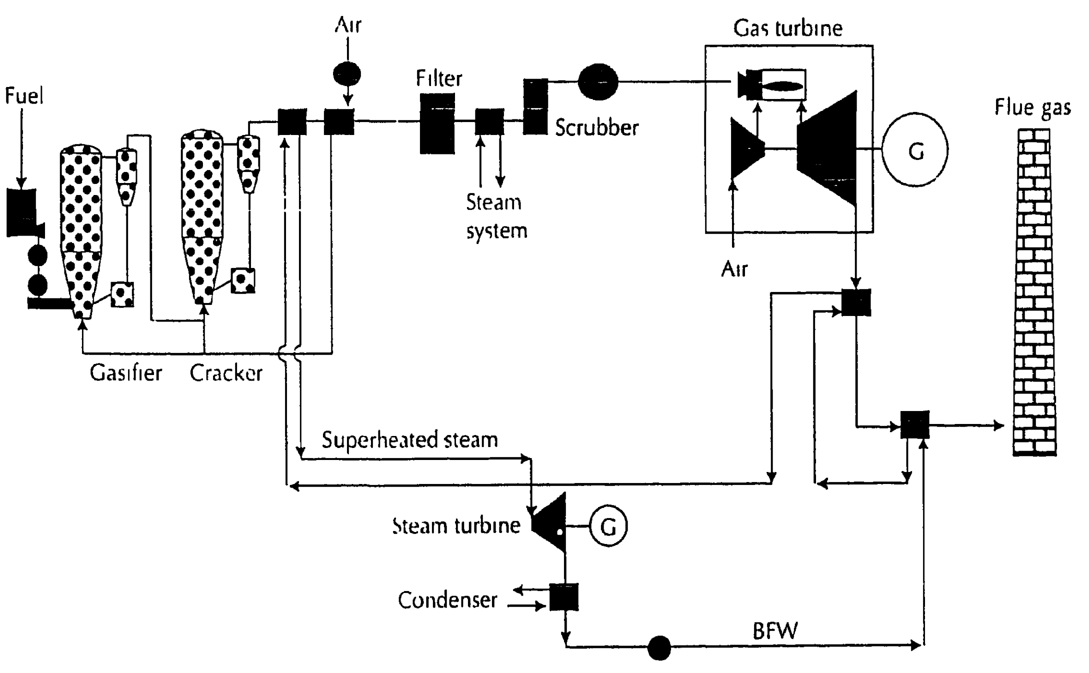


Figure 3. Combined cycle with integrated atmospheric gasifier

by the primary air The larger fuel particles will float in this section as they are pyrolyzed and gasified. Higher up, secondary air is supplied which carries away smaller fuel particles in a circulating fluidized bed. The bed is operated in the 750–900 °C range

The tarry fuel gas containing a small amount of fines leaving the gasifier is then fed into the tar cracking unit. This reactor is built in the same way as the gasifier and has similar dimensions. The gas is introduced together with some air at the bottom and is contacted with the bed material which in this case consists of dolomite at temperatures of 800–900 °C

By the intense contact with the bed and the catalytic activity of the dolomite, tar is decomposed to gaseous compounds. At the same time, the nitrogen containing compounds and hydrogen cyanide will either decompose to nitrogen gas or ammonia Also, carbon containing dust is gasified by air and gases in the tar cracking unit which operates at a temperature somewhat higher than the gasifier.

After heat recovery, during which the temperature is brought down to a level below 200 °C, the gas is cleaned of residual dust in a conventional bag house filter After cooling, some additional condensation of heavy hydrocarbons might occur These species will be absorbed by soot particles contained in the gas and on the filter dust cake

The cleaned gas, with a temperature of about 40 °C, is then compressed and fed into the gas turbine combustion chamber The net efficiency for a 18 MW (e) condensing power plant operating with this process has been estimated at 44% The specific investment was estimated at between 2500 and 3000 US $/kW(e)

The atmospheric circulating fluidized bed gasification process offered by TPS has been demonstrated in a 2 MW (thermal) pilot plant operated for 1700 hours on wood fuels During much of this test period the gas was used to drive a 500 kW diesel generator set, operating in dual fuel mode Attractive features of this process are the relatively simple fuel feeding, the proven gasifier technology, the very clean gas and the use of commercially proven technology for gas cleaning Disadvantages are the need for two large reactor vessels, which can be expected to increase the investment, and the power lost from compression of the product gas to the pressure in the gas turbine combustion chamber, which tends to reduce the cycle efficiency

Integrated pressurized gasifier

With pressurized gasification it is possible to avoid the power consumption of the gas compressor It may also be possible to design a more compact gasifier and gas cleaning equipment than if gasification and gas cleaning is carried out at close to atmospheric pressure

Research related to integrated pressurized gasification of coal for operation of gas turbines is going on in many countries. Research focused on use of biomass as feedstock is now mainly carried out in Finland despite the fact that such research on a large scale was done in Sweden already in the early 1980s.

The company which has come closest to commercialization of integrated pressurized gasification for operation of a gas turbine in a combined cycle is Bioflow AB, a joint venture between the

Finnish equipment vendor Ahlstrom Company and the Swedish utility Sydkraft AB. The Bioflow process, is also considered for the Global Environment Facility project in Brazil A 6 MW(e) plant based on the same process, using wood residue as fuel has been built in Varnamo, Sweden and was in the commissioning phase in early 1995

After drying of the feedstock to about 15% moisture, it is fed into the pressurized gasifier operating as a circulating fluidized bed at 25–27 bar and just below 1000 °C Gasification takes place by partial combustion with air Gasification air is taken after passes through the main compressor and delivered to the gasifier by a booster compressor which compensates for pressure losses in the gasifier and the gas cleaning system

The hot gas leaving the gasifier is cooled with heat recovery to the steam process and enters a hot gas filter operating at 350 °C After filtering to remove dust and alkali metal compounds, the gas flows to the gas turbine combustion chamber

With a General Electric LM2500 gas turbine, and a condensing steam turbine, the plant is estimated to give 30 MW (e) with an efficiency of 45% Capital investment estimates for this capacity are not available The Varnamo pilot plant of 6 MW(e), which is a district heating installation with an electric yield of 33%, has been reported to cost about 3500 US $/kW

The process of pressurized gasification of biomass, including the pressurized hot gas cleaning, has not been demonstrated at operating pressure or a commercial scale unit VTT in Finland has done some research in this field, but is limited to 10 atmospheres Experiments have been done in a 150 mm diameter test rig. The commercial companies that are active in this field have no plant experience from pressurized gasifiers on a commercial scale Ahlstrom Company has delivered several atmospheric circulating fluidized bed gasifiers in the capacity range of 15–35 MW (thermal), which generate fuel gas for lime kilns in pulp mills Until recently, Studsvik, the predecessor of TPS, was the only company that had actually operated above 20 atmospheres This was done in the MINO pilot plant unit of 2 MW (thermal), operating at up to 30 bar in the period 1980–1985 The research was stopped in 1986 due to lack of funding In 1989, Ahlstrom Company built a 10 MW (thermal) pressurized test facility in Karhula, Finland Tampella Company commissioned a gasification test facility with a capacity of 15 MW (thermal) in early 1995, operating at 30 bar and up to 1100 °C

The main advantages of integrated pressurized gasification are the potentially higher efficiency and that the process is slightly less complicated. The main disadvantage are anticipated problems with feeding the solid fuel into the pressurized gasifier and lack of verification of the hot pressurized fuel cleaning

Pressurized biomass combustor

Direct combustion of coal is practised in the pressurized fluidized bed combustion (PFBC) process used by ABB in a few large power plants with combined gas turbine/steam turbine process operating in different parts of the world. The first of these plants has operated since 1992 for cogeneration of electricity and district heating in Stockholm Coal is fed into the pressurized combustor. The combustion gases expand through the gas turbine after removal of large particles in a cyclone The gas turbine, a modified version of the ABB Stal GT 35 model, is adapted

so that it can tolerate a gas with a dust load higher than normal. The inlet temperature to the turbine is lower than in most modern designs in order to avoid problems with deposition and corrosion caused by ash compounds carried with the hot gas into the turbine.

The possibility of using a similar approach for utilization of biomass fuels is currently being studied by the Division of Energy Engineering at the Lulea University of Technology The project is co-financed by the Swedish government, a group of utilities, ABB Carbon and ABB Stal. The objective is to first build a pilot plant of about 4 MW (e) for cogeneration of electricity and district heating in a community in northern Sweden and later build larger capacities of about 25 MW (e). In the spring of 1995 a "bench-scale" test facility with a small gas turbine of 60 kW(e) was being built for tests. The process is illustrated in Figure 4.

The fuel chosen is dried wood powder, at a moisture content of 5% and with a particle size below 1 mm. This is a commercial fuel in Sweden, used as a substitute for fuel oil in a number of large district heating plants. The technology for producing, handling and storage of the wood powder is well-proven

The powdered biomass fuel is fed into a pressurized fuel bin by a special piston feeder From there, the powder is injected by means of steam into the two-stage pressurized combustor, where the first stage is a cycle gasifier, operating at 800 °C or slightly below. Char and most of the ash is separated in the cyclone and collected in the cyclone bottom, to be used as supplementary fuel in the heat recovery steam generator. The hot combustible gas leaving at the top of the cyclone is burned in the second combustor stage and mixed with diluted air to give the desired inlet temperature to the gas turbine.

A somewhat similar arrangement has been tried by Aerospace Research Corporation in the USA. This company operated a 1 MW (e) gas turbine for about 800 hours using oak sawdust as fuel at a site in Red Boiling Springs, Virginia. These tests showed problems with hard deposits on the turbine blades when the inlet temperature to the gas turbine exceeded 800 °C

The forthcoming tests with a 60 kW(e) turbine planned by the group at the Lulea University of Technology will show if a higher inlet temperature is possible with the commercial Swedish wood powder Tests with bagasse and cane trash are also planned if financing can be arranged

The projected total efficiency for the first cogeneration plant giving 4 4 MW(e) is 83% and the electric yield is 29%. The specific investment for this plant has been estimated at US $1600/kW

The main advantage of this process is its simplicity, which is expected to require a lower capital investment than the other options, in particular at small capacities The main disadvantages are lower cycle efficiency, caused by low inlet temperature to the gas turbine, and more fuel Based on the Swedish experiences, the added fuel cost for obtaining the dried, powdered fuel amounts to about US $6/MWh if part of the fuel produced is used for the drying.

Comparative evaluation of the process options

Comparisons between the four options are difficult because all the processes are under development Operating experiences are available for the hot air turbine option but not for the other options Investment estimates are uncertain and not entirely comparable

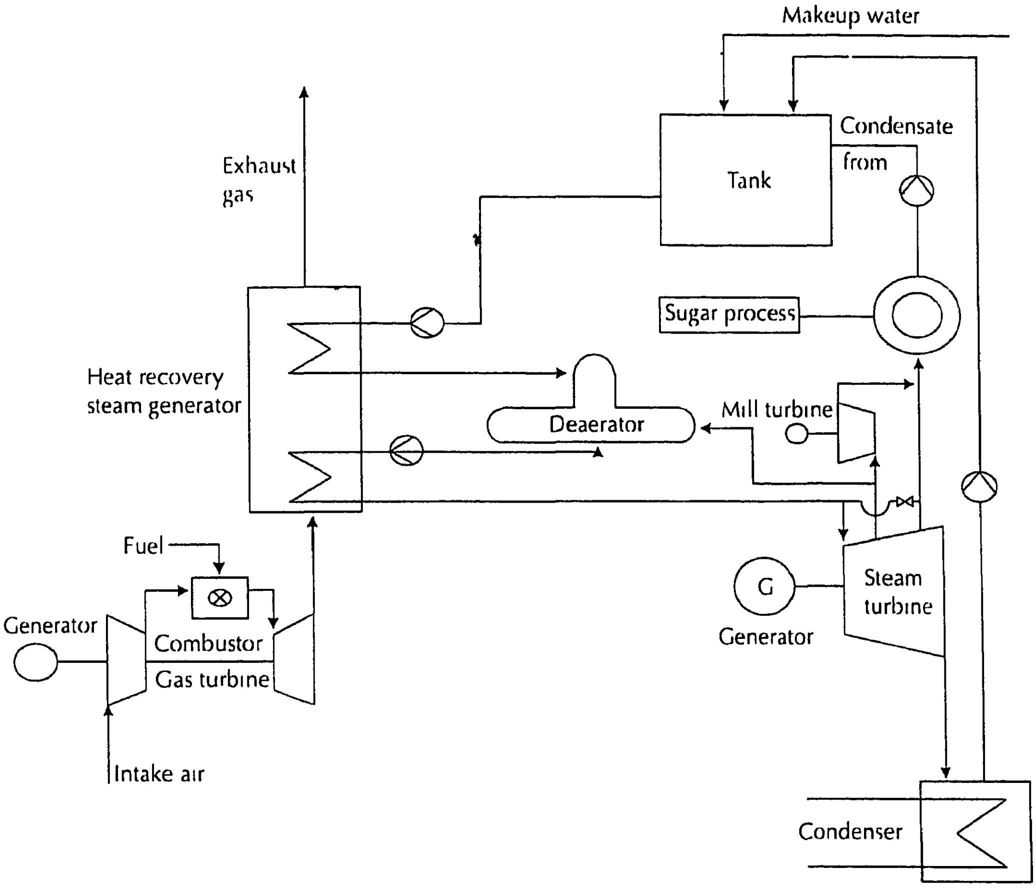


Figure 4 Combined cycle with pressurized biomass combustor

It appears however that pressurized gasification can be expected to give the highest electric yield It also appears that direct combustion may offer the lowest capital investment A rough estimate indicates that a three per cent lower electric yield and a US $6/MWh higher fuel cost would make direct combustion attractive, at an interest rate of 6% and 6000 annual full power hours (assuming further that direct combustion requires US $1600 /kW less in investment) The projected difference is about US $1900/kW at a capacity of about 5MW(e). This indicates that at least for small gas turbine capacities, the direct combustion option may be more attractive than the pressurized gasification option, despite the lower efficiency and higher fuel price for the direct combustion option

Financial constraints

One of the major problems for a firm interested in cogeneration is the relative capital intensity of a cogeneration system The capital cost of a cogeneration system may range from US $500 to US $1000 per kilowatt of installed capacity for oil and gas systems from US $1000 to US $1500 for coal, wood, or biomass systems When in times of high interest rates and credit restrictions, such as those we have recently experienced, this capital intensity makes the financing of such systems a major consideration in their successful development Where the firm's overall economic picture limits its ability to use the tax benefits associated with such projects, third-party ownership is the answer to this problem and has been successfully implemented the world over

Hence, the industries find it difficult to raise resources for the incremental cost of setting up a cogeneration system with the objective to sell surplus power to the utilities. The tax and duty structure on the capital equipment used for the cogeneration facility are not as attractive as in case of other non-conventional energy sources. Liberal credit facilities such as concessional interest rates, larger repayment period etc should be provided to the industries to encourage cogeneration. GOG has already taken steps in this direction. Other concessions should be tax-free status for import of materials and operation of the facility and a concession to establish the company and to provide a legal framework for the sale of electricity to GEC

Legislative constraints

Presently there is no legal framework for the purchase of surplus cogenerated power However, it is believed that the cogenerator will face no legal barriers to sell to GEC. The Guyana Mining Corporation currently sells bulk power to GEC, and similar arrangements are being discussed with sawmill and rice mill operators. As mentioned elsewhere, a private consortium also recently contracted construction of a generation facility for the sale of power to GEC

GEC may also consider wheeling and banking of cogenerated power. It is not certain at this point of time whether legislative changes will be required to allow wheeling and banking of cogenerated power. Long term power purchase contracts between the GEC and cogenerators for purchase of surplus power to encourage industries to opt for cogeneration under power maximization mode

Pricing policy and cost considerations of the cogeneration

One of the most crucial factors in promoting cogeneration relates to agreement on the tariff policy. There is no clear pricing policy for purchase of power. Utilities while carrying out their long-term planning exercise, must consider cogeneration option as a source of firm power supply in relation to conventional power generation options The tariff for cogenerated power should therefore be set at the avoided cost for new capacity added for meeting base load demand

Ideally, the utilities must pay the marginal cost or the avoided cost of their own power generation or purchase from any source other than the cogenerator. Utilities however, under the principles of grid discipline, consider the short term marginal costs (fuel and operating costs) This makes cogeneration option unviable and therefore deters investments by the industries However, under the power maximization option, incremental capacity is added by the industry with the sole objective of supplying to the grid, the cogenerator must be paid both capacity as well as the variable costs. Also, utilities while carrying out their long-term planning exercise, must consider cogeneration option as a source of firm power supply in relation to conventional power generation options.

Pricing of power sales by cogenerators

Electric power in Guyana is supplied by Guyana Electric Corporation (GEC), another public sector company, which generates most of its electricity through 9 plants and manages the grid

Although the total installed capacity of GEC is 75 MW, only about 37 MW is available to the grid because of poor equipment and management

GEC's tariff revenues are low because the present average tariff is lower than the generating cost and also because of inadequate metering and collection methods Neither GEC nor the Government has the financial resources to overhaul the power sector The revised power tariff is shown in the Table 6

For these reasons, the GOG has recently signalled its interest in private investment and operational participation in the power generation sector Additional capital, technical, and managerial resources from the private sector investors from abroad, it is hoped, will avert or otherwise greatly alleviate potential shortfalls in electricity supply

Private sector participation in electricity generation can potentially take several forms, including

- Large power projects (e g , coal, oil, gas, lignite), selling to the GEC, a private utility and/or directly to final users These potentially include planned projects that are identified in the least-cost plan and are solicited from the private sector
  Such projects also include unsolicited but large power projects that are intended to be consistent with the least-cost supply plan for the sector Power projects built to primarily serve large industrial estates fall in this category as well
  For this category of power transactions, the GOG has to indicate price regulation and what form will it take e g , the "two-part tariff" as in India This may be suitable for large hydro projects in Guyana, which lie untapped.
- A second category of transactions involves the sale of surplus power to the grid, from small to medium-size independent power producers (IPPs), that are not identified explicitly in the least-cost plan, but that have access to an economic resource on-site (e g., small hydro, peat, agricultural residue, by-product wastes, wind) and that is broadly consistent with the resource development strategy for the sector.

Table 6 GEC electricity tariff structure

Tariff	Description	Charges
A	Residential	G$ 10 50/kWh
	Minimum charge per month	G$ 400 0
B	Fixed rate	G$ 500 00
	Commercial rate	G$ 16 60/kWh
C	Demand charge	G$ 4000 00/kW (max demand)
	First block	G$ 15 40/kWh
	Second block	G$ 12 60/kWh
D	Demand charge	G$ 400 00/kW (max demand)
	First Block	G$ 14 60/kWh
	Second block	G$ 11 90/kWh
E	Street lighting	G$ 11 44/kWh

Note The above tariff structure became effective on 1 November 1993

A subset of this category of potential power transactions is the sale of excess power by cogenerators.

The primary focus of this report is concerned with the latter category of power transactions in the specific context of the sugar mill and other potential agro-based industry.

The objectives of this section are (i) to apply an appropriate framework and method for pricing potential power sales by cogenerators in the agro-based industry, based on utility avoided costs; and (ii) to estimate appropriate power purchase tariffs for sugar mills

Pricing framework

This section identifies the types of power transactions that can arise in the context of a market for excess power supply from cogenerators. Within the context of the cogeneration power market, the following transactions are generally adopted. These are

- Direct sale to the grid: this transaction involves a cogenerator (sugar mill/saw mill) selling excess power to the SEB grid under a contractually agreed price and under terms stipulated in the power purchase contract between the GEC and the mill owner(s).
- Wheeling: this transaction requires the GEC to transmit the cogenerated power for simultaneous delivery at another location. The delivery could be to a "sister concern" of the seller or to a third party.
  The utility charges a transmission (wheeling) charge, whereas the final purchaser of the electricity pays the cogenerator directly for the power at the agreed price
- Banking this transaction involves a cogenerator selling its excess power to GEC for withdrawal for its own use at a later time
- Banking plus wheeling· this transaction is a variant of the banking concept noted above in that payback of the banked energy involves wheeling the power to a delivery point different from the point of injection. Delivery could be to a "sister concern" of the mill or to a third party

Efficient power purchase tariffs for direct sales to the grid are relatively easier to establish than tariffs for the other transactions listed above, and direct sales to the grid comprise over 99% of the transactions in established power markets worldwide[1]

By contrast setting wheeling tariffs is more complex, and the underlined principles are still a matter of considerable discussion and debate. Even more importantly, transmission access (i e , the use of utility's grid by other parties) is a highly contentious issue and one that goes to the heart of a fundamental question—how best to organize the power sector In particular, should the functions of generation, transmission, and distribution being vertically disintegrated and who has the ultimate responsibility for meeting the consumer load?

[1] The largest cogeneration power market is in the US This market has developed essentially since 1980 Wheeling excess and pricing are two of the major unresolved issues being debated today by regulators and the various stake holders Whatever little wheeling does exist today is to enabling utility, and not to third party end-users

The concept of banking is traditionally found to have limited applications in the power market worldwide. In the instances where it exists, banking has been utilized in bulk power markets in situation in World Bank inter-utility diversity exchanges (e.g , to "firm-up" hydro energy in one season by "storing" it to the another utility's thermal energy capability).

However, given the prevailing institutional and operating environment in Guyana's power sector, a case can be made for all the power transaction categories identified above for reasons other than economic efficiency. For this market to develop, at least initially, it will be necessary for the GEC to encourage prospective suppliers The risk of non-payment by the GEC circumstances favors wheeling and banking/barter.

It may be necessary to introduce a new legislation so that the cogenerators can sell electricity directly to third parties with GOG's approval Third-party sales, if properly structured offer the potential for efficiency gains by enabling the more efficient use of capital

Estimating avoided cost

One way to establish the value of power generated by independent producers is to estimate the "avoided" costs from the perspective of the utility. These are the costs of generation, transmission and distribution, as well as fuel, that the power company no longer needs to incur by virtue of the operation of the independent source This section briefly describes alternate methods for estimating these avoided costs

Avoided energy cost

Avoided energy costs represent incremental fuel and other variable operations and maintenance (O & M) costs of the generation displaced by the purchase These costs, in any hour, are the incremental fuel and other variable expenses saved by backing down the next generating "unit at the margin" This unit that would be backing down may be the most expensive unit running at the time. Alternatively, and depending on the operating environment and other factors and considerations such as area control, reactive load support, etc., the avoided energy cost may be a weighted average of two or more units whose loading levels have to be adjusted as a consequence of the power purchase

Avoided generation capacity cost

For estimating avoided cost for generation capacity, the following methods have been cited and/ or used in various studies

- Peaker method
- Proxy unit methods
- Differential revenue requirements method
- Cost of bulk power purchase method

Peaker method

The 'peaker method' is rationalized on the basis that the least cost means of securing added capacity is a peaking unit such as a gas turbine, which has a low capital and high operating cost. By comparison, other types of generation plants are built at higher capital costs to derive energy savings and lower operating costs. The annualized cost of a peaking unit—adjusted for reserve margin and losses and appropriately discounted from the year of first need to today—is the marginal cost of generation capacity. The following equation captures this calculation.

Marginal generation capacity = [(K) (1 + RM/100)/(1 – SL/100)]
Cost (Rs/coincident kW/yr)

where K = Annualized cost of peaking unit (Rs/kW/yr)
RM = Planning reserve margin(%)
SL = Station losses (%)

This cost (in constant prices) is discounted from the first year in the future when the need for new capacity is anticipated and then adjusted upwards for incremental fixed O & M expenses, as well as any downstream losses up to the point of delivery. Finally, this cost can be allocated to different time periods (e.g. peak and off-peak) A common allocation method is on the basis of the contribution of each rating period to the annual loss of load probability (LOLP)

Proxy unit methods

This class of methods pegs avoided costs to the cost of a specific generating unit that is judged to be a suitable proxy for the power purchase under evaluation One choice for a proxy unit is the next actual unit that is to come on line If several different plants are coming on line within a short period, then one of those could serve as the proxy unit, alternatively avoided cost can be estimated as the average of avoided costs calculated individually for each of these units In the event that the utility is not planning to build any capacity for the foreseeable future, or even if its but none of the committed plants is judged to be a suitable proxy, then one may select a generic representative plant e.g. a plant that the utility may build as a proxy

Once a proxy plant is identified, then avoided capacity costs are estimated as the capacity cost of the proxy plant, adjusted as appropriate. For example, if the proxy unit selected happens to be a coal plant, then it is appropriate to allocate some of the capacity cost to variable cost; the rationale being that baseload plants which are higher capital cost but lower fuel cost (compared to other plants) are built primarily for energy production at lower total cost For meeting capacity requirements, the utility has other lower cost options available

The theoretical line of reasoning under this approach is that a 1 kW power purchase (from the cogenerator) results in delaying the on-time date of the coal plant, resulting possibly in additional fuel costs as a result of having to delay a more fuel efficient plant that will come on line later. For example, if the next plant is 50 MW baseload fuel oil unit expected to come on line in 1997, that its annualized cost discounted to the present less any increase in fuel cost is an estimate of avoided capacity cost.

Differential revenue requirements method

In contrast to the two methods noted above, the differential revenue requirements method requires the use of a sophisticated optimization package for generation expansion planning. Specifically, three "model runs" are required as follows. Run-1 corresponds to optimizing the system generation expansion plan to the base load forecast Model Run-2 reoptimizes the system expansion plan with the peak load forecast used in Run-1 incremented by the equivalent of one year's load growth. Finally, Run-3 is a production simulation[2] to estimate the fuel costs associated with the load forecast used in Run-1, but unit stagings are determined in Run-2. Then, the long run marginal cost (LRMC) for generation capacity is estimated by calculating the following quantity·

$[(CR_1 - CR_2) + (FC_2 - FC_1)]/D$

Where CR_i is the capital investment associated with model run i (i = 1,2,3), FC_i is the fuel (production) cost associated with the expansion plan model run i, and D is the megawatt incremental difference in peak load between runs 1 and 2 The formula calculates savings in capital expenditures for generation system expansion as a consequence of a firm power purchase of magnitude D megawatts from the cogenerator, i e. it represents avoided generation capacity cost This method is too data intensive and costly to have been employed in this study.

Avoided network capacity cost

The transmission and distribution (T & D) network's capacity is designed to accommodate peak demand power flows from generation to end users. Further, in a growing system, such network capacity is sized and sequenced recognizing future growth potential as well. Generally, all investment costs for T & D are allocated to incremental capacity because the designs of these facilities are determined principally by the peak kilowatts that they carry rather than by kilowatt-hours The most frequently used approach for estimating marginal T & D capacity cost, and the one recommended in the present context, is the long run average incremental cost (LRAIC) method

The LRAIC represents the present value of all T & D investments over the planning horizon divided by the present value of the corresponding annual increments in peak load. This value, expressed in US $ per incremental kW, is then annualized over the life of the facilities, resulting in the annualized capacity cost, expressed in US $/kW/year

Separate LRAICs should be estimated for each major voltage level of the network e.g., very high voltage (VHV), high voltage (HV), medium voltage (MV), and low voltage (LV). If for example, 10 MW of cogenerated power are purchased from a plant served at HV, then in the overall power flow balance it will help to serve a 10 MW load in the LV network, less LV network losses. If this is a firm power purchase contract and supply is available year round, then this purchase can receive credit corresponding to the avoided cost of the VHV and HV networks. This

[2] International Atomic Energy Agency's WASP model for optimal generation expansion planning

is because in absence of this purchase, the utility would have to generate this power (plus upstream losses) and expand the network upstream of the plant (i.e. VHV, HV)

Technical barriers and problems of parallel operations

The quality of electric power is a major problem from the utilities side in Guyana, which are - high voltage fluctuations, frequency variations, and frequent power failures. All these factors need to be taken care of while adding to the cost of the cogeneration plant

The cogenerator may have a slightly different set of concerns, such as safety, interconnection costs, production of the cogeneration system, power factor cost, and impact on production

Utility system reliability is also affected by the location of the cogeneration interconnection on the utility system. If the interconnection is at a transmission level, then interruptions of service have greater potential impact than those at a distribution level The utility may require even more stringent protection requirements of cogenerators connected to the transmission system to protect other customers "downstream" of the cogenerator.

Another consideration is the generator size compared to the plant load and the load on the utility life. This will usually result in more stringent protective requirements since the utility and cogenerator will again seek to protect utility and customer equipment from service disruptions.

Harmonic currents are another problems that may be present Harmonic currents occur at frequencies other than the desired 50 Hz of the power signal When transmitted along power transmission and distribution lines, these harmonics distort the power signal

Both the cogenerator and the utility need to protect their respective personnel and facilities from injury and damage that could be caused by generator misoperation This protection often utilizes automatic equipment to detect and isolate the faulty sections of a circuit so that the remainder of the network can continue to deliver power without interruption

When cogenerators are present, several areas of utility planning may be affected because of the dispersed locations of the cogenerators These impacts may show up in voltage regulation, load restoration after interruptions, and sufficient circuit capacity.

Utilities will need to account for deviations from their expected load surveys and load factors caused by dispersed generation. These form the foundation of utility planning Both of these are affected by dispersed generation, which is usually not planned for and displaces some electrical demand as well

Financing cogeneration projects

Cogeneration projects generally involve investment in capital equipment to produce electricity and thermal energy. Such investments produce revenues from the sale of electricity and thermal energy, or reduce the operating costs for the purchase of such energy The financing of a cogen-

eration project is therefore similar to the financing of any capital intensive project. The revenues from the sale of products from the cogeneration project (or the cost reduction resulting from the use of these products) must be sufficient to provide for the operating expenses and produce sufficient returns for the investments made in the project by the financing sources.

In the feasibility study by M/s Schaffers & Associates, the financial results were based on 80% long-term financing, using terms and conditions that are similar to those considered by the IDB and other multi-lateral funding agencies There is, however, every reason to assume that a technically, financially and economically sound project would receive favourable consideration from these funding sources Alternatively, the study suggested for suppliers' credit or export financing by a country that supplies a significant share of the equipment required Both the Export-Import Bank of the United States and the Export Development Corporation of Canada provide financing and guarantee cover for power generation projects The environmental and economic features of electricity cogeneration from bagasse are well-suited to the current policy orientation of these organizations

General considerations in financing cogeneration projects

While cogeneration projects exhibit a tremendous diversity in project size, scope, ownership, financing method and amount of financing required, the following issues must be considered in developing the optimum financing approach

- Credit worthiness—what is the credit rating of the various parties involved in the cogeneration project, and what is their capability to generate the necessary financing?
- Type of financing—what are the different possible methods for financing the project, and what could be the roles of the various parties in developing the financing?
- Financing sources—what are the major sources for the funds required for the cogeneration project, and what portion of the total funds will come from each source?
- Risks and risk sharing—what are the major financial risks presented by the cogeneration project, and who will share the risks and in what proportion?
- Ability to utilize tax benefits—can the project participants take advantage of the available tax benefits, and what is the optimal allocation of the tax benefits to the various participants? This might be beneficial under the new economic policy.
- Requirements of financing sources—what requirements will the major financing sources impose upon the project, and how can these be satisfied?

It is important for project developers to pay adequate attention to all of these issues in order to develop the financing plan that will provide adequate resources for the project and sufficient sharing of risks and benefits to the various project participants

Financing sources

Although there are several industrial financial institutions, financing of cogeneration projects require some special considerations such as cogeneration co-developers and build own operate and transfer, build own operate, build operate transfer (BOOT/BOO/BOT) schemes. Cogeneration project developers (these may mean engineering firms and/or equipment suppliers also) will

find that a number of different sources are available for financing their projects Projects may be financed exclusively from one of these sources, or through a combination of different sources. It is also important to recognize that some of these financing sources will provide equity financing as well as debt to the project. An evaluation of which financing sources would be the most appropriate for a particular project depends on the type of financing commitments, the terms of financing, the size of financing required, and the approach of the financing organization to risk containment and risk sharing. A discussion of some of the common financing sources is given

Commercial banks

Commercial banks are likely to be one of the most common sources for financing cogeneration projects. In particular, medium to large commercial banks are increasingly interested in alternative energy projects and are now convinced that cogeneration projects are attractive for conventional bank financing For large projects, banks may form a consortium to develop the needed financing. The terms of financing from commercial banks can vary significantly from project to project, and may include fixed or variable interest rates, repayment terms ranging from 5 to 15 years, project security requirements ranging from project equipment to other assets of the developer or sponsor, and various types of guarantees or contractual requirements

Insurance companies

Insurance companies have traditionally been excellent sources of financing capital projects and may be interested in cogeneration Insurance companies are generally willing to provide longer terms for financing, ranging from 15 to 20 years. They may be willing to take equity positions in certain projects, in addition to providing debt financing Insurance companies are also likely to be willing to take somewhat higher risks than conventional banks, as long as appropriate rewards are available to them to cover the risks taken

Third-party financing

This type of financing is being practised mostly in the US A number of third-party financing companies have been established for the explicit purpose of financing cogeneration projects. The idea of BOOT/BOT/BOO is also applicable under similar conditions These companies have access to a number of different financing sources and are actively searching for cogeneration projects with the right types of economic returns. Third-party financing has ranged from less than $1 million to several million dollars for some projects Quite often, these third parties have technical knowledge of cogeneration, as well as expertise in the institutional aspects of cogeneration, particularly with respect to state and federal regulations and contract negotiations with utilities and other parties. Also, these developers can take advantage of the available tax benefits and are able to pass some of the benefits to the project sponsors Third-party financing companies are willing and interested in equity positions in projects, and there have been project, selling the project outputs to an industrial firm and/or a utility

These types of developers are quite willing to structure innovative financial arrangements that may benefit all of the parties involved in the cogeneration project. During the last several years, an increasing number of large organizations are expressing interest in third-party financing, and are actively searching for opportunities to finance cogeneration projects

Individual investors

Because of a number of tax benefits offered by cogeneration projects, individual investors represent a potential financing source Limited partnerships can be structured to provide tax benefits, cash flows and potential long-term value to individual investors While individual investors will generally require a greater return on their equity, they are more willing to take greater risks and are also willing to receive their returns over the long term, as long as some immediate tax benefits are available in the short term

Equipment manufacturers

Manufacturers of cogeneration equipment such as boilers, turbines, generators, etc , are increasingly looking to the cogeneration market as an attractive market for the sale of their products. They have recognized that being able to finance such equipment may increase their chances of making the sale to project developers or sponsors Manufacturers are therefore increasingly providing financing to cogeneration projects Some manufacturers have even set up cogeneration financing companies to specifically offer equity and debt financing to cogeneration projects. In the process, they have become "full service" companies that will provide a range of services including feasibility analysis, design, financing, construction, operation and maintenance

Architectural/engineering firms

A number of large architectural/engineering firms, who have traditionally provided services to central station power generation markets, are now turning towards the cogeneration market. They too have recognized that their chances of making a sale increase if they offer other services such as financing These types of organizations are willing to take equity positions in projects and are interested in providing a number of different services beyond design and construction management

Industrial development authorities

For cogeneration projects owned by municipal or public authorities, tax exempt financing through industrial development bonds may be feasible The advantage of such financing is that the debt cost may be reduced substantially over conventional financing methods

Requirements of financing sources

The cogeneration project developer or sponsor must be aware of the major requirements of the financing sources The most obvious and the most critical requirement of a financing source is that the basic project be economically viable. In other words, the project must generate sufficient cash flow to pay all of the project expenses, plus the interest and debt payments, plus a return on the investment of the equity participants. A second major requirement is that the project risks be minimized Most financing organizations want a reasonable assurance that the project interest and debt payments will be met in the future Cogeneration projects involve a number of different risks (as discussed below), and if these risks are considered to be significant, then the financing organization will insist on resource financing requiring the project sponsor to commit his other assets or resources as collateral for the project in case of default on the debt payments In order to minimize the risks and provide protection against long-term uncertainties,

financing organizations will generally require long-term protection. In other words, it will be important for the developer to obtain contracts for his purchase of fuel, as well as for the sale of the thermal and electric energy, such that the long-term prices and costs are bounded within certain limits. If such contract protection cannot be obtained, the financing sources may consider the project inherently risky, and may require other types of protection to assure that the interest and debt repayments will be met by the project developers.

In risky situations, the financing sources will look for a debt coverage ratio on the order of 200%, i.e , the anticipated net cash flows (project revenues minus all project expenses) should be twice the anticipated interest payments and debt repayments If the anticipated revenues and costs are guaranteed through contract protection, then the debt coverage ratio can be smaller.

A final requirement for financing sources is the sharing of benefits proportional to the risks The higher the risk transferred to the financing source, the greater the returns the source is going to expect to receive from the project Therefore, projects involving substantial risks may elect to obtain equity participation by various types of organizations or to establish limited partnerships with investments by individual investors who are willing to take higher risks

Project financing

Financing the projects identified for implementation is an extremely crucial aspect of our energy policy. It is expected that the energy agency to be established would collaborate with the other relevant local agencies/organizations in promoting investments and securing financing for the projects. Financing of these projects could be pursued through various international institutions/countries which include

- Caribbean Development Bank (CAD)
- World Bank
- Inter-American Development Bank (IDB)
- Organization of American States (OAS)
- Canadian International Development Agency (CIDA)
- OLADE
- Overseas Development Administration (ODA) of the United Kingdom
- European Economic Community (EEC)
- Japan International Development Organization Ltd (JAIDO)
- Government of Japan Grant Aid Programme
- Lines of credit from countries like Venezuela, Brazil, Germany, Italy
- Direct investment by American, Canadian, British, Venezuelan, Brazilian, Italian, German, Australian companies/investors on a Finance, Build, Own, Operate and Transfer (FBOOT basis)
- Guyanese companies/investors in joint venture schemes, again on a FBOOT basis

The types of financing that could be made available are listed below.

- Direct short-term/long-term loans at approximately IDB interest unit
- Technical assistance schemes/programmes

Grant and schemes/programmes
Grants
Short-term/long-term credits (lines of credit)

- 100% direct investment by foreign companies
- Partial direct investment by Guyanese companies in joint-venture schemes

Energy purchase agreement between .... sugar mill and ....State Electric Board

THIS DEED OF AGREEMENT is made this day of . (hereinafter called the "Effective Date"), by and between Sugar Mill registered under the .. and having its registered office at (hereinafter called the "Mill") which expression shall unless repugnant to the context or meaning thereof include its successor and assigns as party of the first part and the State Electric Board, a statutory body constituted under the Electricity (Supply) Act, 1948, having its Registered Office at (hereinafter called the "Board") which expression shall unless repugnant to the context or meaning thereof include its successor and assigns as party of the second part

WHEREAS, the Mill is engaged in the business of sugar manufacturing and other businesses incidental thereto in its production facility situated at in the State of .. . more fully described in Annexure I attached hereto and made a part hereof and

WHEREAS, the Board is an operating electric public utility in the State of . ... and,

WHEREAS, the Mill desires to produce electric energy by co-generation mainly by using baggage and to supply part of the electric energy generated by the Mill's facility to the Board and/or such other parties as is agreed between the Board and the Mill (hereinafter called the "Third Parties") and has approached the Government of . through the Board, for permission to do so, and

WHEREAS, the Government of in exercise of its power under Section 44 of the Electricity (Supply) Act 1948, has permitted the Mill to generate and supply such electric energy with capacity up to MW and feed to the grid, by the letter dated ., and

WHEREAS, in pursuance of the said permission, the Mill has undertaken to supplement the existing co-generation facilities by installing plant and equipment to have generation capacity of MW in its production facility and to complete erection, installation and commissioning of the said capacity to make it operational by . , and

WHEREAS the Mill desires to sell to the Board and/or to the agreed Third Parties, electric energy generated in the Mill's facility, and the Board wishes to purchase such energy or agrees to such energy being delivered to Third Parties upon the terms and conditions set forth herein

NOW, THEREFORE, in consideration of premises and mutual agreements, covenants and condition set forth herein, it is hereby agreed by and between the parties as follows.

Energy purchase and sale

1 1 0 The Board shall purchase and accept all energy made available directly to the Board's system from the Mill's facility, which the Mill shall sell and deliver pursuant to the terms and conditions of this Agreement at the basic rate of Rs 2 10 per kWh (as in the Financial Year 1995/96), subject to annual adjustment in the same proportion as the change in the rate charged by the Board for High Tension supply to its customers All taxes, duties and other levies imposed by the Central or State Government or other local authorities shall be borne and payable by the Board No additional payment on any account shall be payable by the Board

1 2 0 For the purpose of supply of energy the time of year will be divided into "Peak Season" and "Off Peak Season" and the time of day into "Peak" and "Off Peak" These time periods shall be as follows

Time Period	From	To
Time of Year		
Peak Season	16 September	14 June
Off Peak Season	15 June	15 September
Time of Day.		
Peak	06 00	22.00
Off Peak	22 00	06.00

The above basic rate will apply to energy supplied during Off Peak Time-of-Year and Off Peak Time-of-Day Premium of 10% shall be paid by the Board for supply in On Peak Time-of-Day.

1 3 0 In consideration of the purchase, the Board shall also be entitled to a share of reactive power The share shall be in accordance with the capability curve of the Mill generator and shall be made available by the Mill without any extra charge

1 3.1 If, at any time, during the peak period, the Mill is required to reduce generation of active power to make available the level of reactive power required by the Board, such reduction in active power shall be considered as "Deemed Generation" for the Board and shall be paid for by the Board at the applicable rate

1 3 2 In case the Mill fails to meet the dispatch requirements of reactive power during a peak period, the amount payable to the Mill for energy supplied during such period shall be reduced in the proportion of reactive power actually generated to the reactive power required to be dispatched

1 4 0 The said rate shall not apply to the supply of electricity by the Board to the Mill supplied under the existing High/Low Tension tariff agreement of supply executed between the Board and the Mill for such supply shall be charged by the Board to the Mill as provided in the above Agreement

1 4 1 The payment to the Board under the tariff agreement will remain unaffected and will not be linked with this agreement obligations of the parties to this Agreement

1.5 0 Minimum level of supply of energy by the Mill to the Board's system shall be as follows.

During crushing season-(Minimum of days) MW or kWh/day
During Non-crushing season-(Minimum of . days) MW or .kWh/day

1 6 0 During crushing and non-crushing season the energy sent out in each Billing Month during 10 00 pm to 6 00 am shall not exceed one third of energy sent out during 6 00 am to 10 00 pm in that month

Maintenance requirements of the mill

The Mill's annual maintenance requirements are from .. to . . The Mill shall inform the Board of any changes in the maintenance requirements at least one week in advance

Supply plan

In the last week of every month the Mill shall furnish to the Board a Supply Plan indicating the total quantum of electricity likely to be delivered during On peak and Off peak periods and the shutdown periods, if any, planned during the month

Billing procedure and payments

4.1 0 The Mill shall raise monthly bills based on the quantities of electric energy delivered by the Mill to the Board during the previous calendar month (Billing month) according to the time of day delivered, either on peak or off peak.

4 2 0 The invoice shall be delivered to the Board at its designated office on or before the fifth (5th) working day of the following month hereinafter called the Invoice date The Board shall make full payment on such invoice to the Mill within 30 working days of the receipt of the invoice A blank invoice and sample invoice are illustrated in Annexure II & III attached hereto and made a part hereof

4 3 0 Payment shall be made by an irrevocable revolving letter of credit of value equal to the billable amount of the maximum amount of energy to be supplied in any one month opened in favour of the Mill by the Board's Bank

4 4 0 Any payment not made to the Mill on or before the 30th working day after receipt of the invoice by the Board shall accrue interest at a rate three per cent more than the highest prevailing rate charged for long term loans by the Industrial Development Bank of India until the outstanding interest and invoiced amounts are paid in full. Partial payments, if made by the Board shall be applied first to outstanding but unpaid interest and then to outstanding but unpaid invoiced amounts

4 4 1 If payment is still due to be made on the 61st day after receipt of the invoice by the Board the late payment by the Board shall be deemed a Delinquent payment

4 4 2 Delinquent payments may be forwarded, by the Mill, to the Bank of hereinafter called the Bank Upon receipt, the Bank will pay the Mill from the account held by the Board and in which revenue receipts of the Board are credited

4.4 3 The Board shall remain in default of payment until the Mill has been paid in full, from whatever source, including interest under Section .

4 5 0 Details of the agreement between the Mill, the Board and the Bank are given in and attached hereto as Annexure and made a part hereof

Parallel operations

The Board shall allow the Mill to interconnect and operate with the Board's system subject to the terms and provisions of this Agreement

Generation facilities owned and operated by the mill

The Mill shall furnish, install, own, operate and maintain equipment more fully described in Annexure The Mill shall follow such operating procedures on its side of the electric interconnection point with the Board's system as are consistent with applicable laws and rules, and the terms and conditions of this Agreement

All electrical equipment shall be furnished and installed consistent with the requirements of the Chief Electrical Inspector, Government of . ...

The Mill further agrees to make no material changes or additions to its facility which may have an adverse effect on the Board's system, or amend the single-line diagram relay list and/or trip scheme of Annexure I without the Board's prior written agreement The Board agrees that such agreement shall not be unreasonably withheld

Without limiting the foregoing, the Mill shall install, operate, and maintain its facility in accordance with accepted good engineering practices in the electric industry The Mill's operation and maintenance schedule and staffing shall be adequate to meet this standard at all times

The Board shall follow such operating procedures on its side of the electric interconnection point with the Mill as required to accept energy from the Mill's facility without any avoidable interruptions or adverse effect on the Mill and consistent with applicable laws and rules, and the terms and conditions of this Agreement

Interconnection facilities

It shall be the responsibility of the Mill to provide at its own cost, operate and maintain fully equipped Line Bay/s in its switchyard for termination of the interconnecting line/s of the Board.

The Line Bay/s shall include all equipment for interconnection of the Mill's facility with the grid of the Board

The Board shall provide at its own cost an independent and dedicated line/s from its sub-station to the Mill switchyard and the equipment required at its sub-station for interconnection and accepting energy from the Mill into the Grid

The Mill and the Board shall consult with each other and jointly decide on the scheme for protection of the interconnecting line/s and of the facilities at both ends, and accordingly provide the equipment at their respective ends

Without limiting the foregoing, the Mill and the Board shall install, operate and maintain its facility for interconnection and parallel operation in accordance with accepted good engineering practices in the electric industry The Mill's operation and maintenance schedules and staffing shall be adequate to meet this standard at all times

All electric equipment shall be furnished and installed consistent with the orders of the Chief Electrical Inspector, Government of

The interconnection facilities, to be owned by the Mill and the Board, are set forth in Annexure attached hereto and made a part hereof

Protective equipment and interlocking

The interconnection facilities shall provide necessary protective equipment and interlocking devices, which shall be so co-ordinated that any malfunctioning or abnormality in the generators or in the bus of the Mill shall not adversely reflect or affect the Board's grid system In the event of any malfunctioning or abnormality the Mill's breaker shall trip first to protect the equipment The Mill shall obtain approval of the Board for the protection logic of the generator system and synchronization schemes

It shall be the responsibility of the Mill to avoid back feeding of supply from the Grid to their co-generating system.

Technical assistance by the board and mill's responsibility

On request, the Board shall provide reasonable technical assistance to the Mill in preparing design and specifications of the required facilities and also for laying down the standard operating and maintenance procedures

Notwithstanding providing of such technical assistance by the Board, the Mill shall be responsible for procurement, installation, testing, maintenance and operation of the co-generation system In any event, the Board shall not be responsible for any damage caused to the

generating set and other parts of the co-generation system of the Mill, on account of any mistake or defect in the design, procurement, installation, testing, maintenance and operation of the system

Arrangements at the point of supply

The Mill shall make all arrangements for paralleling the set/s with the Board's grid at the point of supply, in consultation with and to the satisfaction of the Board, subject to the approval of the Chief Electrical Inspector, Government of .

Synchronization

The Mill shall synchronize its power generating set in consultation with the operating staff of sub-station of the Board The Mill shall give seven days prior intimation of synchronizing programme (i) when commissioning of the co-generation system for the first-time, (ii) on start of crushing season, and (iii) after completion of its annual maintenance programme, to .... and the office of . . . . sub-station of the Board

The Board shall not be responsible for the damage, if any, caused to the plant and equipment of the Mill due to failure of the synchronizing or the protective system provided by the Mill

Integrated operation

The Mill shall run the generating set and co-generating system unit as a part of integrated system to generate power in parallel with the Grid

Liaison with and assistance from the buyer

The Mill shall closely liaise with designated officials of the Board during the period of co-generation. During the period this Agreement is in force the Mill shall inform the date of commencement of delivery of power to designated officials of the Board one month in advance and also arrange for testing and commissioning of the protection system well in advance If requested by the Mill, the Board shall extend the assistance for the purpose of testing, subject to condition that the Mill shall pay the charges for such assistance to the Board as would be notified or indicated by the concerned testing division of the Board

Metering

The Board as well as the Mill shall each supply, own, install and maintain two identical sets of TOD meters for measuring energy exported from and imported into the Mill along with all necessary associated equipment These meters shall be installed in the Mills premises The meters of the Board shall be the "Billing Meters" and shall be utilized for determining the quantity of energy supplied by the Mill to the Board and by the Board to the Mill during different time periods, for the purpose of billing by the respective party The meters of the Mill shall be termed

"Mill Meters" and serve as "check meters" The meters shall be of 0 5 accuracy class and shall comply with the technical standards, accuracy and calibration requirements of the Indian Electricity Rules

The Mill shall provide, at no expense to the Board, a suitable location for installing meters and associated equipment used for billing and energy purchase

The meter readings shall be recorded in the format given in Annexure VII

The Board shall, at least once in each year during the term hereof, test all the metering equipment for accuracy, in the presence of a representative of the Mill, if the Mill elects to have a representative present

The meter test results shall be jointly certified by the Board's designated representative and the representative of the Mill After every testing all metering equipment shall be securely sealed jointly by the representatives of the Board and the Mill

The reading and testing of the meters and the associated equipment shall be in accordance with accepted good engineering practices in the electric industry

Calibration, inspection and testing of the meters and the associated equipment shall be the responsibility of the owner, who shall bear the related costs

If the difference between the readings of the Billing and the Mill Meters, in any billing month, is found, after testing, to be differing by more than one per cent, an adjustment for the full amount of such inaccuracy in past billings will be made within 30 working days by one party to the other on the basis that any inaccuracy so discovered shall be conclusively presumed to have existed for half (1/2) the period between the last meter test and the meter test in which the inaccuracy was discovered In such event, both the meters shall be compulsorily tested and recalibrated by the Board in presence of the Mill's representative

Acceptance and approval of the board

The Board's acceptance or approval of equipment, additions, or changes in equipment and their operational setting is required, such acceptance shall not be unreasonably withheld and shall be based on the Board's existing policies and practices.

Commissioning of cogeneration facilities

The Mill shall commission the co-generation facilities and synchronize with the Board's grid not later than In exceptional circumstances, the Mill and the Board may agree to extend the commissioning date up to maximum of one crushing season

In case commissioning is delayed beyond the agreed or extended commissioning date, the Mill shall pay to the Board penalty of 0 5% of the capital cost for each completed 30-day period of delay, with maximum of 5% of the capital cost.

Continuity of service

The Board may require the Mill to temporarily curtail or interrupt deliveries of energy only when necessary in the following circumstances

(i) for the Board to repair, replace, remove any of its equipment or any part of its system that is associated with the Mill's facility;

(ii) if the Board determines that the continued operation of the facility may endanger the safety of the Board's personnel or integrity of the Board's electric system, or have an adverse effect on the electric service to the Board's other customers, or

(iii) under *Force Majeure* condition

Any necessary inspection, investigation or maintenance of the Board's equipment or any part of its system that is associated with the Mill's facility shall be planned by the Board to coincide with the scheduled outage of the Mill's co-generation system

If the Board disconnects the Mill from the Board's system, it shall immediately notify the Mill by telephone and confirm in writing the reasons for and the likely period of the disconnection During the period so notified the Board shall not be obligated to accept or pay for any energy from the Mill, except for such energy that the Board notifies the Mill that it is able to take during this period.

In any such event as described above the Board shall take all reasonable steps to minimize the number and duration of such interruptions, curtailments, or reductions

The Board shall avoid scheduling any event as described in (1) above to the extent reasonably practical during the Mill's operations Where the scheduling of such an event during the Mill's operations cannot be avoided, the Board shall provide the Mill with at least days advance oral notice with subsequent written confirmation of the event to allow the Mill to cease delivery of energy to the Board

If the Board fails to comply with the provisions of subsection, as per the Electricity Supply Act, the energy not delivered shall be deemed to have been delivered, and the Board shall pay the full price of the energy as if the curtailment, described in subsection, as per the Electricity Supply Act, had not occurred

A claim by the Board that an event referred to in subsections, as per the Electricity Supply Act has occurred or will occur is subject to verification by the Mill including, but not limited to inspection of equipment, records and interviews with Board staff

In order to allow the Mill's facility to remain on-line and to minimize interruptions to Mill operations, the Mill may provide automatic equipment that will isolate the Mill's facility from the Board's system during large system disturbances.

Notwithstanding anything contained hereinabove, the Mill shall not be entitled to and the Board shall not be liable to pay any compensation on account of non-drawal of energy due to an uncontrollable situation in the grid or in any other circumstances beyond control of the Board.

Daily report

The Mill shall submit daily generation report in the form annexed as Annexure VI to this Agreement to the . irrespective of energy generation or no generation.

Monthly report

The Mill shall submit a monthly report in the form given in Annexure VII to ... . on or before third day of each month

Inspection

Inspection of premises of the Mill by any Board's official without prior permission or intimation to the Mill shall be allowed during normal office working hours of the Mill

Clearances, permits, and licenses

The Mill shall obtain, at the Mill's expense, all authorizations, permits and licenses required for the construction and operation of the Mill's facilities and any interconnection facilities, including but not limited to rights-of-way or easements The Board shall provide reasonable assistance to the Mill to obtain the same if so requested by the Mill with costs to be reimbursed to the Board up to an amount mutually agreed upon in advance

Duration

Except where terminated by default, this Agreement shall be firm for 20 years from the date of commercial operation of the co-generation plant

It shall continue to be in force thereafter unless terminated by either party by giving written notice of termination date or if both the parties decide to renegotiate the Agreement

Events of default and termination

The occurrence of any of the following events at any time during the term of this Agreement shall constitute an Event of Default by the Mill

- Failure to pay to the Board any amount payable and due under this Agreement within 60 calendar days after receipt of invoice, or
- Failure on the part of the Mill to use reasonable diligence in operating, maintaining or repairing the Mill's facility, such that the safety of persons and property, the Board's equipment, or the Board's service to others is adversely affected, or
- Failure or refusal by the Mill to perform its material obligation under this Agreement; or

- Abandonment of its interconnection facilities by the Mill or the discontinuance by the Mill of services covered under this Agreement unless such discontinuance is caused by *Force Majeure* or an event of default by the Board

The occurrence of any of the following at any time during the term of this Agreement shall constitute an Event of Default by the Board

- Failure to pay to the Mill any amount payable and due under this Agreement within 60 calendar days after receipt of invoice; or
- Failure to use reasonable diligence in operating, maintaining or repairing the Board's interconnecting facilities, such that the safety of persons and property, the Mill's equipment, or the Mill is adversely affected, or
- Failure or refusal by the Board to perform its material obligation under this Agreement, or
- Abandonment of its interconnection facilities by the Board or the discontinuance by the Board of services covered under this Agreement, unless such discontinuance is caused by *Force Majeure* or an event of default by the Mill

Except for failure to make any payment due within 60 calendar days after receipt of invoice, if an Event of Default by either party shall extend for a period of 60 calendar days after receipt of written notice of such Event of Default from the non-defaulting party, then the non-defaulting party may, at its option, terminate this Agreement by delivering written notice of such termination to the party in default

The non-defaulting party may also institute such legal action or proceedings or resort to such other remedies as it deems necessary; provided, however, that except for failure to make any payment due, the party, not in default shall not terminate this Agreement at the end of such sixty (60) day period if the party in default has corrected or commenced appropriate steps to correct such default and is diligently pursuing the same to completion or has instituted to conflict resolution provisions of of this Agreement and is diligently pursuing the same to completion Such termination shall be effective on the date of written notice of termination to the party in default and shall not prejudice any rights of the non-defaulting party

Failure by either the Board or the Mill to exercise any of its rights under this Agreement shall not constitute a waiver of such rights. Neither party shall be deemed to have waived any failure to perform by the other unless it has made such waiver specifically in writing

Either the Board or the Mill may terminate this Agreement upon notice to the other party, if the Mills facility fails to begin producing electric energy within three (3) years from the planned commercial operational date shown in Annexure I The date of initial production of electric energy may be extended up to a maximum of one crushing season in the event of occurrence of a *Force Majeure* condition

Disputes and arbitration

Both the parties shall comply with the provisions of this Agreement and discharge the respective obligations in the event the acceptance is withheld and the issue is unresolved, a meeting shall be

held by of the Mill and of the Board to resolve the issues In case the issues are still unresolved provisions as per the Electricity Supply Act shall apply

All differences or disputes between the parties arising out of or in connection with these presents including any question or matter of dispute which falls within the scope and purview of the statutory authorities under the provisions of Electricity (Supply) Act 1948 as amended from time to time that the parties are unable to resolve by mutual agreement shall be submitted to binding arbitration in in the State of as provided herein

In the event of such differences or disputes, between the parties, either party may be given written notice of 30 days to the other party seeking arbitration The arbitration shall be conducted in accordance with the provisions of Arbitration Act 1940 and statutory notifications issued under the Act

Any such rule to the contrary notwithstanding, the issue under arbitration shall be heard and decided by a panel of three arbitrators, of whom one arbitrator shall be designated by the Mill, one arbitrator shall be designated by the Board, and the third shall be selected by mutual agreement of the other two

The arbitrators shall give written award normally within one month of the start of the arbitration proceedings In special circumstances, the Arbitrators, with the consent of the parties, may extend the time for giving and publishing the award by minimum period necessary.

The arbitrators shall reasonably decide in what proportion the fee payable to them and cost of arbitration proceedings shall be borne by the parties

The decision of the arbitrators in any such arbitration on the issue or issues submitted to them including the sharing of the costs of arbitration, and joined in by at least two of the members of such panel shall be final, non appealable and binding upon the parties and may be enforced in any court of competent jurisdiction in the state of

Notwithstanding the existence of any question, disputes and differences referred to arbitration, the parties hereto shall continue to perform their respective obligations under this agreement and the payment of any bill preferred shall not be withheld by the Board for any reason whatsoever including the pendency of arbitration

Payment of settlement of dispute

The Board shall pay for such electric energy that the Mill would otherwise have delivered and the Board could otherwise have taken

- If it is subsequently agreed by the Board or determined, pursuant to the terms of Section .. . or that no occurrence of events described in Section . took place, or
- If it is subsequently agreed by the Board or determined pursuant to the terms of Section . or that an occurrence of Section did take place but was unnecessary or could have reasonably completed sooner

Indemnification

The Mill shall indemnify, defend and hold harmless the Board and its directors, officers, employees and agents, and their respective heirs, successors, legal representatives and assigns, from and against any and all liabilities , damages, costs, expenses (including attorney fees), losses, claims, demands, actions, causes of action, suits, and proceedings of every kind, including those for damage to property of any person or entity (including the Mill) and/or for injury to or death of any person (including the Mill's employees and agents), which directly or indirectly result from or arise out of or in connection with negligence or wilful misconduct of the Mill

The Board shall indemnify and hold harmless the Mill and its directors, officers, employees, and agents, and their respective heirs, successors, legal representatives and assigns, from and against any and all liabilities, damages, costs, expenses (including outside attorney fees), losses, claims, demands, actions, causes of action, suits and proceedings of every kind, including those for damage to the property of any person or entity (including the Board) and/or injury to or death of any person (including the Board's employees and agents), which directly or indirectly result from or arise out of or in connection with the negligence or wilful misconduct of the Board

Assignment

This Agreement may not be assigned by either the Board or the Mill without the consent in writing of the other party, except that either party may assign its rights under this Contract, or transfer such rights by operation of law, to any corporation with which or into which such party shall merge or consolidate or to which such party shall transfer all or substantially all of its assets; provided that such assignee or transferee shall expressly assume, in writing, delivered to the other to this Agreement, all the obligations of the assigning or transferring party under this Agreement.

Force majeure

If any party hereto shall be wholly or partially prevented from performing any of its obligations under this Agreement by reason of or through lightning, earthquake, riots, fire, flood, invasion, insurrection, rebellion, mutiny, tidal wave, civil unrest, epidemics, explosion, the order of any court, judge or civil authority, change in State or National law, war, any act of God or the public enemy, or any other similar or dissimilar cause reasonably beyond its exclusive control and not attributable to its neglect, then and in any such event, such party shall be excused from whatever performance is prevented by such event to the extent so prevented, and such party shall not be liable for any damage, sanction or loss resulting therefrom

The party invoking this clause shall satisfy the other party of the existence of such an event and give written notice within seven to fifteen days to the other party and take all possible steps to revert to normal conditions

In the event of a *Force Majeure* condition developing, any payment due under this Agreement shall be made as provided herein and shall not be withheld

Authority to execute

Each respective party represents and warrants as follows

Each respective party has all necessary rights, powers and authorities to execute, deliver and perform this Agreement

The execution, delivery, and performance of this Agreement by each respective party will not result in a violation of any law or result in a breach of any government authority, or conflict with, or result in a breach of, or cause a default under, any agreement or instrument to which either respective party is a party or by which it is bound No consent of any person or entity not a party to this Agreement, including any governmental authority, is required for such execution, delivery and performance by each respective party

Liability and dedication

Nothing in this Agreement shall not create any liability to any person not a party to it

No undertaking by one party to the other under any provision of this Agreement shall constitute the dedication of that party's system or any portion thereof to the other party or to the public, or shall it effect the status of the Board as a public utility or constitute the Mill or the Mill's facility as a public utility

Nodal agency of the buyer

The of the Board shall act as a nodal agency for implementing this Agreement.

Amendments

Any waiver, alteration, amendment or modification of this Agreement or any part hereof shall not be valid unless in writing and signed by the parties

Binding effects

This Agreement shall be binding upon and inure to the benefit of the parties hereto and their respective successors, legal representatives, and permitted assigns

Notices

Any written notice provided hereunder shall be delivered personally or sent by registered post, acknowledgement due, or by courier for receipted delivery, with postage or courier charges prepaid, to the other party at the following address.

Board

Notice delivered personally shall be deemed to have been given when it is delivered to the office of the . . . to the Mills or to the office of the .... of the Board at address set forth above and actually delivered to such person or left with a responsible person in such office Notice sent by post or courier shall be deemed to have been given on the date of actual delivery as evidenced by the date appearing on the acknowledgement of delivery

Any party hereto may change its address by giving written notice of such change to the other party hereto.

Effect of section and annexure headings

The headings or titles of the several sections and annexures hereof are for convenience of reference and shall not affect the construction or interpretation of any provision of this Agreement

Non-waiver

No delay or forbearance of either party in the exercise of any remedy or right will constitute a waiver thereof, and the exercise or partial exercise of a remedy or right shall not preclude further exercise of the same or any other remedy or rights

Relationship of the parties

Nothing in this Agreement shall be deemed to constitute either party hereto as partner, agent or representative of the other party or to create any fiduciary relationship between the parties.

Entire agreement

This Agreement constitutes the entire understanding and agreement between the parties

Governing law

This Agreement shall be governed by and construed in accordance with the laws of the State of . ...

No party deemed drafter

The parties agree that no party shall be deemed to be drafter of this Agreement and that in the event this Agreement is ever construed by an arbitrator, or a court of law, they shall not construe this Agreement or any provision hereof against either party as the drafter of the Agreement, the Board and the Mill acknowledging that both parties have contributed substantially and materially to the preparation of this Agreement

Approvals

Wherever either Board or Mill approvals are required in this Agreement, it is understood that such approvals shall not be unreasonably withheld

Attorney's fees and costs of litigation

In the event that a dispute between the parties is submitted to arbitration, to the courts, or to some other conflict-resolution procedure, the prevailing party shall be entitled to an award of its court costs, other costs of litigation, and reasonable attorneys' fees

Standard for decision-making

All operational decisions or approvals that are to be made the discretion of either the Board or the Mill pursuant to the terms of this Agreement, specifications, and design criteria, shall be made or performed according to good engineering practice in the electric industry Professional decisions or activities undertaken by either party for the purpose of constructing, installing, removing, maintaining or operating any facility which may affect the operations of the other party's facility or facilities shall be made or performed according to good engineering practice in the electric industry

IN WITNESS WHEREOF, the Board and the Mill have executed this Agreement as of the day of . in the year .

For the Mill by Its	For the Mill by Its
Witnessed by	Witnessed by
Name Designation Address	Name Designation Address.

Annexure I

The mill and cogeneration facilities

1 **The mill:**

Name

Location·

Chief Executive·

Contract person

Mailing address

Telephone number

Fax number·

Emergency telephone number

Payment mailing address·

2. **Generating equipment:**

Boilers

Turbo-generator set

Generation voltage

Speed

Type of governor

Transformer·

First synchronization with kV line (initial operation date)

Commercial operation date

Stipulations relating to the facilities

For the purpose of this agreement the Mill's facility includes all real estate, fixtures, and property owned, controlled, operated or managed in connection with or to facilitate the production, generation, transmission, delivery, or furnishing of electricity owned by the Mill and required to interconnect and deliver the electric energy to the Board's system A single-line diagram, relay

'list, and trip scheme, reviewed and accepted by the Board, of the Mill's facility at the time the Agreement is signed, shall be attached to this agreement and made part hereof The single-line diagram, relay list, and trip scheme shall expressly identify the point of electrical interconnection of the Mill's facility to the Board's system Material changes or additions to the Mill's generating and interconnection facilities reflected in the single-line diagram, relay list, and trip scheme shall be approved by the Board pursuant to Section of the Agreement.

The Mill shall furnish, install, operate and maintain facilities such as breakers, relays, switches, synchronizing equipment, monitoring equipment and control and protective devices acceptable to the Board as suitable for parallel operation with the board's system. Such facilities shall be accessible to authorized Board personnel for inspection on giving prior intimation to the Mill.

The Mill shall furnish, install, operate and maintain in accordance with the board's requirements, all conductors, service switches, fuses, meter sockets, meter and instrument transformer housing and mountings, switchboard meter test buses, meter panels, and similar devices required for service connection and meter installation on the Mill's premises

The Board shall review and approve the design drawings and Bill of Material for the Mill's electrical equipment required to interconnect with the Board's system The type of electrical equipment, the type of protective relaying equipment and the setting that affect the reliability and safety of operation of the Board's and Mill's interconnected system shall be approved by the Board The Board, at its option, may request to witness operation of control, synchronizing and protection schemes

The Mill shall provide a manual disconnect device, which provides a visible break to separate the Mill's facilities from the Board's system Such disconnect device shall be lockable in the OPEN position and be readily accessible to Board personnel at all times

Operating procedures

The Board's Load Dispatcher shall advice the Mill by 22.00 hr The hourly schedule for generation of active and reactive power by the Mill on the following day

Logs shall be kept by the Mill on unit availability, including reasons for planned and forced outages, circuit breaker trip operations, relay operation, including target initiation; and other unusual events, if known The Board shall have the right to review these logs, especially in analysing system disturbances The Mill will provide the Board with subsequent written confirmation any time the Mill experiences a unit trip Such confirmation will include the date and time of the occurrence as well as the cause of the unit trip, if known

The Mill shall limit their ramp rate to less than 2 MW/min

The Board may require periodic reviews of the Mill's facilities, maintenance records, available operating procedures, relay settings, and request changes it deems necessary, in compliance with safety and good engineering practice.

If the Mill is separated from the Board's system for any reason, the Mill under no circumstances, shall recharge into the Board's system without first obtaining specific approval to do so from the

Board's Load Dispatcher. Such approval shall be withheld only when such re-closing is not in accordance with the Board's standard practices and procedures.

The Board's Load Dispatcher will notify the Mill whenever the Mill must be separated from the Board's system pursuant to Section .... and .. . of this Agreement. When possible, reasonable advance notice will be given to the Mill by the Board's Load Dispatcher.

The Mill's normal annual maintenance requirements are from .. to ..

The Mill shall notify the Board's Load Dispatcher prior to synchronizing a generator on to or taking a generator off the system. Such notification should be as far in advance as reasonably possible under the circumstances causing the action

Interconnection facilities provided by the Mill

Line basis

Item	Provided	Not provided
Structures		
Bus bars, clamps, and connectors		
Grounding grid		
Isolators		
Current transformers		
Circuit breakers		
Control cubicles		
Control cabling		
AC/DC power supply		
Communication equipment		

Synchronization and protection facilities

Item	Provided	Not provided
Automatic voltage regulator		
Auto synchronization unit		
Protection for internal faults		
Differential generator		
Differential unit transformer		
Restricted earth fault		
Stator earth fault		
Rotor earth fault		
Inter-turn fault		
Over voltage		
Loss of excitation		
Under voltage		
Reverse power		
Protection for grid faults		
Minimum impedance		
Unbalance (negative phase sequence)		
O/C & E/F (unit transformer)		
Overload alarm		
Protection for grid disturbances		
Under frequency		
Pole slip		

Annexure II

Synchronization interconnection and protection facilities

Generator capacity	Less than 4 MW	4 MW to 15 MW	15 MW to 60 MW
Automatic voltage regulator	Necessary	Necessary	Necessary
Auto synchronization unit	Necessary	Necessary	Necessary
Protection for internal faults			
Differential generator	Necessary	Necessary	Necessary
Differential unit transformer	Necessary	Necessary	Necessary
Restricted earth fault	X	Optional	Necessary
Stator earth fault	Necessary	Necessary	Necessary
Rotor earth fault	Optional	Necessary	Necessary
Inter-turn fault	X	X	Necessary
Over voltage	Necessary	Necessary	Necessary
Loss of excitation	Necessary	Necessary	Necessary
Under voltage	Necessary	Necessary	Necessary
Reverse power	Necessary	Necessary	Necessary
Protection for grid faults			
Minimum impedance	X	Optional	Necessary
Unbalance (negative phase sequence)	Optional	Necessary	Necessary
O/C & E/F (Unit transformer)	Necessary	Necessary	Necessary
Overload alarm	Necessary	Necessary	Necessary
Protection for grid disturbances			
Under frequency	Necessary	Necessary	Necessary
Pole slip	X	X	Necessary

Annexure III

Rate schedule

Initial rates, effective from for payment to the Mill by Board for energy delivered by the Mill to Board shall be

	Rs/kWh
Off-Peak Time-of-Year energy rates	–
Off peak rate Rupees per kWh	2 00
On peak rate Rupees per kWh	2 20
On Peak Time-of-Year energy rates	–
Off peak rate Rupees per kWh	2 20
On peak rate Rupees per kWh	2 42

Annexure IV

Meter readings of cogenerating mill

Reading should be taken on last day of every month, at 12 00 noon.

Time-of-Year : Peak / Off Peak ·

Name of the Mill ·

Place *Taluka* · District State

CT Ratio available/connected ·
PT Ratio available/connected ·
Scale factor (if any) ·
Multiplying factor (MF)
Billing meter make/number

Meter readings ·

	On peak	Off peak
KWh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh generated		
kVarh scheduled		

Executive Engineer/Chief Engineer,

. . Board . . Mill

Date

Notes

1 The Mill shall maintain a daily log-book to record hourly readings of the Billing /Meter / HT meter reading of energy delivered
2 The Mill shall maintain a daily log to record the hourly generation of kWh and kVarh and the schedule given by the Board's Dispatcher
3 If the meter is changed, the reason/s, date, time of meter change and new meter make, and number must be recorded

Annexure V

Daily cogeneration report

Name and address of Mill Date

Installed generation capacity MW
Surplus generation capacity MW

Time	Active power			Reactive power		
	Scheduled	Meter reading	Difference × MF	Scheduled	Meter reading	Actual generation
00						
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
Total						

	Active power			Reactive power		
	scheduled	Meter reading	Difference x MF	Scheduled	Meter reading	Actual generation
Daily						
0600–2200						
2200–0600						
Cumulative						
0600–2200						
2200–0600						

To

1. Chief Engineer, ... Board
2. Executive Engineer, . . Board

Chief Engineer
. . .. Mill

Monthly tripping report
(Cogeneration)

Name and Address of the Mill

Installed generation capacity MW Surplus generation capacity MW
Date of first commissioning (synchronizing) Date of commercial operation
Date of synchronizing (current season)· Progressive days (cogeneration)
Date of start of crushing season· Progressive crushing season days

Progressive Days : during crushing season Time lost During Month
Off season Year

Since first Commissioning Since first Commissioning

Tripping on fault

S no	Tripping			Relay operated	Reason for tripping			Synchronizing			Total time lost		REMARKS
	Date	Time			Mechanical	Electrical	Other	Date	Time				
		Hr	Min						Hr	Min	Hr	Min	

Planned and forced outage

S no	Outage			Reason				Synchronizing			Total time lost		REMARKS
	Date	Time		No Cane	Mechanical	Electrical	Other	Date	Time				
		Hr	Min						Hr	Min	Hr	Min	

Annexure VI

Invoice

For the Month of . ...

Season peak/off peak

Invoice No Date

Name of the Board Address Town PIN Code Tel 0000 0000000 Fax 0000 00000000	Dr	Name of the Mill Address Town District PIN Code Tel 0000 0000000 Fax 0000 0000000

Meter readings

	On peak	Off peak
kWh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh generated		
kVarh scheduled		

Description	Quantity	Unit price	Amount
kWh supplied—off peak			
kWh supplied—on peak			
Less A/C shortfall in kVarh generation/kWh			
Add			
		Subtotal	
		Tax	
		Total due	

For Mills Ltd

Authorized Signatory

Annexure VII

Invoice

For the Month of

Season Peak/ Off Peak

Invoice No Date

Name of the Board Address Town PIN Code Tel 0000 0000000 Fax 0000 00000000	Dr	Name of the Mill Address Town District PIN Code Tel 0000 0000000 Fax 0000 0000000

Meter readings

	On peak	Off peak
kWh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh		
Previous reading		
Current reading		
Difference		
Difference × multiplying factor		
kVarh generated		
kVarh scheduled		

Description	Quantity	Unit price	Amount
kWh supplied—off peak			
kWh supplied—on peak			
Less A/C shortfall in kVarh generation/kWh			
Add			
		Subtotal	
		Tax	
		Total due	

For Mills Ltd

Authorized Signatory

Annexure VIII

Bank agreement

This is to be a contract between the BOARD and the Bank principally responsible for the administration of the receipts of the BOARD This contract is to provide the Mill with a senior position against the receivables of the BOARD. In the event of non-payment by the BOARD to the Mill the Bank will be authorized to transfer funds from the account of the BOARD to the account of the Mill to satisfy the delinquent amount owed the Mill by the BOARD This agreement must contain the following

1 Define the terms of the agreement

2 Define parties to the agreement

3 Define interest to be paid by BOARD for late payment

4. Define order of obligation retirement (i e interest first)

5. Require that in the event of a change of Bank by the BOARD the new Bank will assume the obligations required under the banking agreement

6 Notification to the Mill by the BOARD in the event of a change of Bank by the BOARD.

7. Define the critical operative dates and periods

8 Provide notification provisions by the Bank to the BOARD when payments are made by the Bank to the Mill

9 Provide notification provisions by the Mill to the Bank and the BOARD when payments are delinquent and the Mill is requesting payment by the Bank

10 Define notification provisions by the Bank to the Mill for minimum balance in the accounts against which delinquent payments will be drawn

11 Define the accounts against which delinquent payments to be made to the Mill will be drawn

12 Define the senior position of the Mill against the account of the BOARD *vis-a-vis* claims by others

13. Provide for automatic payment by the Bank for delinquent payments even in dispute and correction for disputed payments after dispute resolution under the Energy Purchase Agreement

14 Provide that the Bank will make payment to the Mill within five working days upon receipt of notification of a delinquent payment by the Mill

15 Provide that the BOARD and the Mill must seek resolution of payment disputes under the Energy Purchase Agreement and not under the Banking Agreement

Wheeling and banking supplement

With prior mutual understanding with the Board, the Mill may supply all or part of the electric energy generated by the Mill's facility to such other parties as are end-users and are acceptable to both the Board and the Mill [hereinafter called the "third party (parties)"], upon the terms and conditions set forth herein

The supply to third party (parties) may be through

- Wheeling or Banking, using the Board's grid, or

- Radial feeders

Wheeling shall involve real time supply from the Mill to the Third Party (parties) by transmitting the energy through the Board's grid The energy shall be withdrawn for end-use at the same time or within a short interval of time, not exceeding 24 hours from the time of supply

Banking shall involve retaining of the energy supplied by the Mill in the Board's system for use by the end-user at some other time, within an agreed maximum time interval

Wheeling or Banking could be to

- Units owned by or associated with the Mill at the same or different location
- Other units at the same or different location

The Mill may bank energy for its own use under the same terms as are applicable to third parties.

Energy supplied by the Mill shall be drawn by the end user in the same time period, off-peak or on-peak

Such supply shall not be affected by any restriction the Board may put on the use of energy generated by the Board's own facilities

The Board shall be compensated for the use of the Grid for Wheeling, by retaining of 7% of the energy wheeled. For every 100 units of energy wheeled, the Board shall supply 93 units to the end-user The compensation for banking of energy shall be by retaining of 10% of the energy banked

The price of the energy wheeled or banked shall be as mutually agreed between the Mill and each third party The Board shall have no liability in this respect except for delivering wheeled or banked energy of standard quality as agreed between the Mill, the Board and the third party

The Mill shall prepare a monthly supply plan showing the quantities of electric energy it proposes to deliver to each party through Wheeling and Banking according to the time of day for delivery, either on peak or off peak The plan shall be provided to the Board at least seven days in advance of beginning of the month

Within seven days of the end of a month, the Board shall provide to the Mill a statement showing, party-wise, the quantities of wheeled and banked energy received from the Mill and supplied to the respective parties This statement shall be based on meter readings jointly taken and recorded by the authorized representatives of the Mill, the Board and the end-user parties

The Mill, the Board and the third party (parties) shall enter in to a Wheeling and Banking Memorandum of Understanding laying down the relevant terms and conditions

Event of default by the board

Failure on the part of the Board to deliver electric energy designated under agreement between the Mill and the Board for Wheeling or Banking to the third party (parties) or to the Mill shall constitute an Event of Default by the Board and shall be dealt with as provided in this Agreement

Wheeling/banking memorandum

The Memorandum of Understanding between the designated third party recipient of Wheeled/ Banked energy, the Mill and the Board shall include the following

The memorandum shall contain the following

1 List of third party (parties) recipient of Wheeled and Banked energy, specifying quantities and time-of-day for each party

2 Duration of memorandum of understanding

3 Pricing agreed between the Mill and the third party.

4 Guarantees (if any) between the Mill and the third party

5 Procedure for the Mill to notify the third party of Wheeled or Banked energy and for accounting between the Mill, the Board and the third party

6 Procedure for the Mill to invoice the third party and a blank as well as sample invoice from the Mill to the third party

Note Items 1 and 2 above must have agreement of the Board

Radial supply

With prior agreement of the Board, the Mill may supply energy from its facilities to third party (parties) through a radial feeder (feeders) set up at its own cost, the length of any feeder not exceeding 25 kilometres The Board shall not be responsible or liable in respect of such supply

Contract model for GEC power purchase from Guyana sugar industry

Background

A model for a special power purchase agreement designed specifically for the sugar industry must still contain all of the relevant items of more comprehensive agreements In this case, we can outline the needs and then use a standard cogeneration agreement as an example. A first cut has been made in drawing up a model and both the outline and the first draft agreement follow. This should be viewed as the starting point and not the finished product.

Outline of bagasse cogeneration contract standard offer: as-delivered energy (and capacity)

Introduction

- Purpose
- Scope
- Definition of parties

Legal authority

- Legislation
- Authority vested in GEC
- Certification of status of license
- Authority vested in private generator

Description of private generator's plant

- Location
- Technology
- Sizing/capacity rating
- Fuel supply
- Expected operating conditions

Plant certification

- Responsibilities design/construction
- Applicable technical standards
- Government certification
- Proposer's statement of conformance
- GEC rights of inspection
- Approval and commissioning

Environmental and safety certification

- Applicable environment standards
  - Smoke
  - Particulate
  - Ash and disposal
  - Noise
- Environmental certification
- Applicable safety standards
  - Annual boiler inspection
  - Operator's license
  - Plant safety inspections
- Safety certification

Operation

- Responsibility for daily operation
  - Identification of plant manager
  - Reporting, log books
- Load dispatch
  - Dispatch authority/control
  - Procedure/communications
- Outages
  - Scheduled outages
    - Daily
    - Monthly
    - Yearly
  - Forced and partial outages
    - Estimate of frequency
  - Notification
    - Party to be notified
    - Communications
  - GEC right of entry and inspection

Grid interface

- Definition of interfaces
  - O/H lines and rating
  - Transformers
  - Switchgear
  - Synchronization/phasing
  - Fault detection/load trip-out
  - Metering equipment and methods
  - Technical performance standards
  - Synchronization/frequency stability
  - Voltage and stability
  - Power factor

- Harmonics
- Isolation
- Construction, finance, and maintenance responsibilities
  - By GEC
  - By private generator

Power deliveries

- Scope of deliverables
  - Annual MWh
  - Seasonal MWh
  - Peak MW/MVA
- Measurement
  - Meter reading
  - Frequency
  - Recording
- Obligation to purchase
  - GEC purchase obligation
  - Curtailment due to hydro spill conditions
  - Provision of back-up power

Pricing

- Principles
  - Avoided cost methodology
  - Identification of marginal unit(s) in service
- Rate schedule
  - Off-peak energy
  - On-peak energy
  - As-delivered capacity
  - Frequency of revision
- Adjustments
  - Heat rate adjustment
  - Fuel price index
  - Power factor/line loss adjustment
  - Price escalation index

Payments

- Calculation
  - Computational formulas
- Invoicing
  - Preparation
  - Frequency
- Disbursement
  - Mode
  - Terms

Terms of agreement

- Contract duration
- Unilateral termination
- Notices
- Renegotiation
  Mutual agreement

Standard terms and conditions

- Access to GEC records and data
- *Force Majeure*
- Indemnity
- Liability
- Several obligations
- Non-waiver
- Assignment
- Insurance

As-delivered capacity and energy power purchase agreement between ______________________ and GEC

________________ ("Seller") and GEC referred to collectively as "parties" and individually as "Party", agree as follows

Article 1 · qualifying status

Seller warrants that, at the date of first power deliveries from Seller's Facility[1] and during the term of agreement, its Facility shall meet the appropriate qualifying facility requirements established as of the effective date of this Agreement

Article 2 purchase of power

(a) Seller shall send and deliver and GEC shall purchase and accept from the Facility having a nameplate rating of ______________ kW located at ________________________ the as-delivered capacity and energy at the voltage level of __________ kV Seller has chosen ____________________[2] as its energy sales option. Seller may convert its energy sale option as provided in Section A-3 of Appendix A

(b) The scheduled operation date when Seller estimates first delivery of electric energy from the Facility to GEC is ______________________ At the end of each calendar quarter Seller shall give to GEC written notice of any change in the scheduled operation date

[1] Underlining identifies those terms which are defined in Section A-1 of Appendix A

[2] Insert either "net energy output" or "surplus energy output" to show the energy sale option selected by Seller

(c) To avoid exceeding the physical limitations of the intermediate facilities, Seller shall limit the Facility's actual rate of delivery into the GEC system to ___________ kW.

(d) The primary energy source for the Facility is Bagasse plus ______________.

(e) If seller does not begin construction of its Facility by ________________, (date) GEC may reallocate the existing capacity in GEC's transmission and/or distribution system which would have been used to accommodate Seller's power deliveries to other uses. In the event of such reallocation, Seller shall pay GEC for the cost of any upgrades or addition to GEC's system necessary to accommodate the output from the Facility. Such additional facilities shall be installed, owned, and maintained in accordance with the applicable GEC tariff

(f) The transformer loss adjustment factor is __________________ %

Article 3 purchase price

GEC shall pay Seller for as-delivered capacity at prices authorized by GEC and which are derived from GEC's calculated energy savings.

Article 4 notices

All written notices shall be directed as follows

to GEC   GEC
Main Street
Georgetown, Guyana

Attn ______________________________

to Seller ______________________________
____
____
____
____

Article 5 designated switching centre

The designated GEC switching centre shall be, unless changed by GEC

____
Name

____
Location

____
Phone number

Article 6 terms and conditions

This Agreement includes the following appendices which are attached and incorporated by reference

Appendix A. General terms and conditions
Appendix B Energy prices
Appendix C. As-delivered capacity prices
Appendix D Interconnection

Article 7 terms of agreement

This Agreement shall become effective on the date of execution by the Parties and shall remain in effect until terminated by Seller.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by their duly authorized representatives and effective as of the last date set forth below

____________________ GEC
Seller

By· __________ By __________

Type Name	Type Name
Title __________	Title __________
Date Signed	Date Signed

Typical project structure

The GEC/sugar industry programme aims to significantly improve the efficiency of bagasse utilization in the main sugar mills in Guyana, thereby improving overall energy efficiency in the mills and enabling the production of additional bagasse for use as fuel to cogenerate surplus electricity for export to the grid The programme would provide additional revenues to the sugar industry through electricity sales, at the same time contributing to GEC's power supply and minimizing investment of public funds in new capacity

The ideal project would involve an investment programme to upgrade the sugar mills whereby each participating mill would be retrofitted to enable the production of electricity and bagasse substantially over and above internal mill requirements The basic investment in each mill would typically involve the

(a) addition of a high-pressure boiler;

(b) addition of a topping turbo alternator,

(c) installation of a bagasse drying system which uses waste heat from the boiler flue gases, and

(d) modification of the mill's electrical system to enable interconnection with the utility grid and dispatch of surplus power.

The exact retrofit equipment and investment costs would vary from mill to mill depending on the grinding capacity of the particular sugar mill, whether the retrofit investment would be undertaken in conjunction with capacity expansion. The export power from bagasse cogeneration would be seasonal unless either a supplementary fuel is used or tremendous increases in sugar mill efficiencies are achieved allowing storage of bagasse for off-season firing The seasonal availability during the grinding period (November–April) coincides with GEC's months of high thermal demand due to minimum availability of hydropower

Off-season fuel alternatives

Availability of an inexpensive off-season fuel might or might not improve the financial/economic return of bagasse cogeneration projects This opportunity applies to the electricity maximizing investment configurations, which can operate in a condensing mode during the non-grinding season (about 210 days/year, allowing for maintenance) at reasonable fuel to electricity conversion efficiency The idea is that year round sales of electricity serves to spread the investment capital over a large number of kilowatt-hours, reducing the unit cost of electricity production proportionately, if the season fuel is inexpensive.

Candidate off-season fuels in Guyana include the following

(a) Excess bagasse could be produced at neighbouring mills. Because of spontaneous combustion risks, the excess bagasse has to be baled, pelletized or briquetted for storage USAID is sponsoring on-going bagasse baling trials in Hawaii, Jamaica, and Thailand Pelletizing has been tried with discouraging results in Hawaii due to rapid wearing of the die

(b) Cane field trash recovery is practiced at the Romana mill in the Dominican Republic, and on an experimental basis at the Hacienda Luisita mill in the Philippines. The above mentioned USAID field trials aim at reducing collection and baling costs through introduction of appropriate equipment

(c) Other agricultural and forest industry residues, such as rice straw, sawdust, and offcuts may be available at unknown costs at certain Guyanese mills

(d) Fuel oil is easily combusted in properly designed solid fuel boilers.

(e) Coal is an obvious off-season alternative. Colombian and Venezuelan coal could be considered; however, this still requires foreign exchange and thus is not of primary interest.

Fuel availability concerns aside, the key question becomes. how inexpensive must the supplementary fuel be? A sugar mill's willingness to pay for an off-season fuel will be based on two factors.

- the efficiency of the installed boiler and extraction-condensing turbo alternator in converting the fuel into electricity for export sale, and
- the value of the additional electricity that can be produced during the off-season A quick calculation using economic prices can be made by utilizing the assumption that, the marginal cost of producing off-season electricity is the fuel cost. Operations and maintenance costs are ignored, causing a small distortion Capital investment in the extraction-condensing turbine is considered a sunk cost for a mill choosing to invest in the maximum electricity alternative

A 5–10 extraction-condensing turbo alternator as used in the surplus electricity bagasse cogeneration cycle operates at a relatively low overall efficiency. Typically, the overall fuel to busbar efficiency is 17% At this efficiency, the break even economic cost of energy at the turbine inlet can be calculated

This calculated benchmark may be compared with the estimated economic costs of alternative fuels The experience predicted conclusion is that none of the listed fuels will be sufficiently inexpensive to warrant use as an off-season fuel The basic explanation is that the bagasse cogeneration investments depicted herein are economically attractive because the fuel is essentially "free", that is, a certain quantity of bagasse has to be combusted by the sugar mill for process steam requirements in any case The savings from this free fuel when also used to produce electricity is sufficient to offset the capital cost of the necessary equipment Excess bagasse available on site costs handling charges when delivered to the boiler, and therefore may be profitably burned for in-season additional electricity when no higher-value uses are available, i e paper, fibreboard, etc

Once additional (off-season) fuel is sought, it ceases to be free The sugar mill boiler/turbines are then competing against relatively efficient GEC equipment A typical sugar mill installation might require about 1.25 kg of high ash coal to produce one kWh, a GEC power station probably needs only 0 79 kg to generate the same unit of electricity. The fuel cost disadvantage of the sugar mill can outweigh the economic gain from greater firmness in energy supply

This is not to say that each project proposed should not evaluate its own unique situation It only suggests that unless the supplementary fuel is available at a small nominal charge (perhaps transport plus small incentive payment), the cost of the off-season kWh will be too high to be competitive at a time when GEC does not need the power This must be addressed in the power purchase agreement.

Appendix A: general terms and conditions

A-1 Definitions

Whenever used in this Agreement, appendices and attachments hereto, the following terms shall have the following meanings

Designated GEC switching centre That switching centre or other GEC installation identified in Article 5

Facility· That generation apparatus described in Article 2 and all associated equipment owned, maintained, and operated by Seller

Interconnection facilities All means required and apparatus installed to interconnect and deliver power from the Facility to the GEC system including, but not limited to, connection, transformation, switching, metering, communications, and safety equipment, such as equipment required to protect (1) the GEC system and its customers from faults occurring at the Facility, and (2) the Facility from faults occurring on the GEC system or on the systems of other to which the GEC system is directly or indirectly connected Interconnection facilities also include any necessary additions and reinforcements by GEC to the GEC system required as a result of the interconnection of the Facility to the GEC system.

Net energy output· The Facility gross output in kilowatt-hours less station use and transformation and transmission losses to the point of delivery. Where GEC agrees that it is impractical to connect the station use on the generator side of the power purchase meter, GEC may, at its option, apply a station load adjustment

Prudent electricity practices Those practices, methods, and equipment, as changed from time to time, that are commonly used in prudent electrical engineering and operations to design and operate electric equipment lawfully and with safety, dependability, efficiency, and economy.

Special facility Those additions and reinforcements to the GEC system which are needed to accommodate the maximum delivery of energy and capacity from the Facility as provided in this Agreement and those parts of the interconnection facilities which are owned and maintained by GEC at Seller's request, including metering and data processing equipment All special facilities shall be owned, operated, and maintained pursuant to GEC's normal policy.

Station use Energy used to operate the Facility's gross output in kilowatt-hours, less station use, and any other use by the Seller, and transformation and transmission losses to the point of delivery into the GEC system

Terms of agreement: The period of time during which this Agreement will be in effect as provided in Article 7

Voltage level: The voltage at which the Facility interconnects with the GEC system, measured at the point of delivery.

A-2 Construction

A-2 1 Land rights

Seller hereby grants to GEC all necessary rights of way and easements to install, operate, maintain, replace, and remove the special facilities, including adequate and continuing access rights on property of Seller. Seller agrees to execute such other grants, deeds, or documents as GEC may require to enable it to record such rights of way and easements. If any part of GEC's equipment is to be installed on property owned by other than Seller, Seller shall, at its own cost and expense, obtain from the owners thereof all necessary rights of way and easements, in a form satisfactory to GEC, for the construction, operation, maintenance, and replacement of GEC's equipment upon such property. If Seller is unable to obtain these rights of way and easements, Seller shall reimburse GEC for all costs incurred by GEC in obtaining them GEC shall at all times have the right of ingress to and egress from the Facility at all reasonable hours for any purposes reasonably connected with this Agreement or the exercise of any and all rights secured to GEC by law or its tariff schedules.

A-2 2 Design, construction, ownership, and maintenance

(a) Seller shall design, construct, install, own, operate, and maintain all interconnection facilities, except special facilities, to the point of interconnection with the GEC system as required for GEC to receive as-delivered capacity and energy from the Facility. The Facility and interconnection facilities shall meet all requirements of applicable codes and all standards of prudent electrical practices and shall be maintained in a safe and prudent manner A description of the interconnection facilities for which Seller is solely responsible is set forth in Appendix D or if the interconnection requirements have not yet been determined at the time of the execution of this Agreement, the description of such facilities will be appended to this Agreement at the time such determination is made.

(b) Seller shall submit to GEC the design and all specifications for the interconnection facilities (except special facilities) for review and written acceptance prior to their release for construction purposes GEC shall notify Seller in writing of the outcome of GEC's review of the design and specifications for Seller's interconnection facilities Any flaws perceived by GEC in the design and specifications for the interconnection facilities will be described in GEC's written notification. GEC's review and acceptance of the design and specifications shall not be construed as confirming or endorsing the design and specifications or as warranting their safety, durability, or reliability. GEC shall not, by reason of such review or lack of review, be responsible for strength, details of design, adequacy, or capacity of equipment built pursuant to such design and specifications, nor shall GEC acceptance be deemed to be an endorsement of any such equipment. Seller shall change the interconnection facilities as may be reasonably required by GEC to meet changing requirements of the GEC system

(c) In the event it is necessary for GEC to install interconnection facilities for the purposes of this Agreement, they shall be installed as special facilities

(d) Upon the request of Seller, GEC shall provide a binding estimate for the installation of interconnection facilities by GEC.

A-2 3 Meter installation

a) GEC shall specify, provide, install, own, operate, and maintain as special facilities all metering and data processing equipment for the registration and recording of energy and other related parameters which are required for the reporting of data to GEC and for computing the payment due Seller from GEC

b) Sellar shall provide, construct, install, own, and maintain at Seller's expense all that is required to accommodate the metering and data processing equipment, such as, but not limited to, metal-clad switchgears, switchboards, cubicles, metering panels, enclosures, conduits, rack structures, and equipment mounting pads

c) GEC shall permit meters to be fixed on GEC's side of the transformer. If meters are placed on GEC's side of the transformer, service will be provided at the available primary voltage and no transfer loss adjustment will be made If Seller chooses to have meters placed on seller's side of the transformer, an estimated transformer loss adjustment factor of two per cent, unless the parties agree otherwise, will be applied

A-3 Energy sale options

A-3 1 General

Seller has two energy sale options, net energy output or surplus energy output. Seller has made its initial selection in Article 2 (a)

A-3 2 Energy sale conversion

a) Seller is entitled to convert from one option to the other 12 months after execution of this agreement, and therefore at least 12 months after the effective date of the most recent conversion, subject to the following conditions:

- Seller shall provide GEC with a written request to convert its energy sale option
- Seller shall comply with all applicable tariffs on file and contracts in effect between the parties at the time of conversion covering the existing and proposed (i) facilities used to serve Seller's premises and (ii) interconnection facilities.
- Seller shall install and operate equipment required by GEC to prevent GEC from serving any part of Seller's load which is served by the facility and not under contract for GEC standby service. At Seller's request, GEC shall provide this equipment as special facilities.

b) If, as a result of an energy sales conversion, Seller no longer requires the use of interconnection facilities installed and/or operated and maintained by GEC as special facilities under a special facilities agreement, Seller may reserve these facilities, for its future use, by continuing its performance under its special facilities agreement. If Seller does not wish to reserve such facilities, it may terminate its special facilities agreement.

If Seller's energy sale conversion results in its discontinuation of its use of GEC facilities not covered by Seller's special facilities agreement, Seller cannot reserve those facilities for future

use. Seller's future use of such facilities shall be contingent upon the availability of such facilities at the time Seller requests such use If such facilities are not available, Seller shall bear the expense necessary to install, own, and maintain the needed additional facilities in accordance with GEC's applicable tariff.

A-4 Operation

A-4 1 Inspection and approval

Seller shall not operate the facility in parallel with GEC's system until an authorized GEC representative has inspected the interconnection facilities and GEC has given written approval to begin parallel operation Seller shall notify GEC of the facility's start-up date at least 45 days prior to such date GEC shall inspect the interconnection facilities within 30 days of the receipt of such notice If parallel operation is not authorized by GEC, GEC shall notify Seller in writing within five days after inspection of the reason authorization for parallel operation was withheld.

A-4 2 Facility operation and maintenance

Seller shall operate and maintain its facility according to prudent electrical practices, applicable laws, rules, tariffs and shall provide such reactive power support as may be reasonably required by GEC to maintain system voltage level and power factor. Seller shall operate the facility at the power factors or voltage levels prescribed by GEC's system dispatcher or designated representative If Seller fails to provide reactive power support, GEC may do so at Seller's expense

A-4 3 Point of delivery

Seller shall deliver the energy at the point where Seller's electrical conductors (or those of Seller's agent) contact GEC's system as it shall exist whenever the deliveries are being made or at such other point or points as the parties may agree in writing The initial point of delivery of seller's power to the GEC system is set forth in Appendix D

A-4 4 *Operating communications*

a) Seller shall maintain operating communications with the designated GEC switching centre The operating communications shall include, but not be limited to, system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, levels of operating voltage or power factors, and daily capacity and generation reports

b) Seller shall keep a daily operations log for each generating unit which shall include information on unit availability, maintenance outages, circuit breaker trip operations requiring a manual reset, and any significant events related to the operation of the facility. If Seller makes deliveries greater than one megawatt, Seller shall measure and register on a graphic recording device power in kW and voltage in kV at a location within the facility agreed to by both parties

d) If Seller makes deliveries greater than 1 MW and up to and including 10 MW, Seller shall report to the designated GEC switching centre, twice a day at agreed upon time for the current day's operation, the hourly readings in kW of capacity delivered and the energy in kWh delivered since the last report

e) If Seller makes deliveries of greater than 10 MW, seller shall telemeter the delivered capacity and energy information, including real power in kW, reactive power in kVAR, and

energy in kWh to switching centre selected by GEC GEC may also require Seller to telemeter transmission kW, kVAR, and kV data depending on the number of generators and transmission configuration Seller shall provide and maintain the data circuits required for telemetering. When telemetering is inoperative, Seller shall report daily the capacity delivered each hour and the energy delivered each day to the designated GEC switching center

A-4 5 Meter testing and inspection

a) All meters used to provide data for the computation of the payments due to Seller from GEC shall be sealed, and the seals shall be broken only by GEC when the meters are to be inspected, tested, or adjusted

b) GEC shall inspect and test all meters upon their installation and annually thereafter. At Seller's request and expense, GEC shall inspect or test a meter more frequently. GEC shall give reasonable notice to Seller of the time when any inspection or test shall take place, and Seller may have representatives present at the test or inspection. If a meter is found to be inaccurate or defective, GEC shall adjust, repair, or replace it at its expense in order to provide accurate metering

A-5 Payment

GEC shall mail to Seller not later than 30 days after the end of each monthly billing period (i) a statement showing the kilowatt-hours delivered to GEC during on-peak, partial-peak, and off-peak periods during the monthly billing period, (ii) GEC's computation of the payment due to the Seller, and (iii) GEC's check in payment of said amount. Except as provided in section A-6, if within 30 days of receipt of the statement Seller does not a make a report in writing to GEC of an error, Seller shall be deemed to have waived any error in GEC's statement, computation, and payment, and they shall be considered correct and complete.

A-6 Adjustments of payments

a) In the event adjustments to payments are required as a result of inaccurate meters, GEC shall use the corrected measurements described in Section A-4 6 to recompute the amount due from GEC to Seller for the as-delivered capacity and energy delivered under this Agreement during the period of inaccuracy

b) The additional payment to Seller or refund to GEC shall be made within 30 days of notification of the owing party of the amount due.

A-7 Access to records and GEC data

Each party, after reasonable written notice to the other party, shall have the right of access to all metering and related records including the operations logs of the facility.

A-8 Curtailment of deliveries and hydro spill conditions

a) GEC shall not be obligated to accept or pay for and may require Seller to interrupt or reduce deliveries of as-delivered capacity and energy (1) when necessary in order to construct, install, maintain, repair, replace, remove, investigate, or inspect any of its equip-

ment or any part of its system or (2) if it determines that interruption or reduction is necessary because of emergencies, forced outages, *force majeure*, or compliance with prudent electrical practices.

b) In anticipation of a period of hydro spill conditions, GEC may notify Seller that any purchases of energy from Seller during such period shall be at hydro savings prices quoted by GEC. If Seller delivers energy to GEC during any such period, Seller shall be paid hydro savings prices for those delivered in lieu of prices which would otherwise be applicable. The hydro savings prices shall be calculated by GEC using the following formula:

$$\frac{\Delta QF - S}{\Delta QF} \times PP$$

where.

ΔQF = Energy, in kWh, projected to be available during hydro spill conditions all qualifying facilities under agreements containing hydro saving price provisions

S = Potential energy, in kWh, from GEC hydro facilities which will be spilled if all sugar industry thermal output is delivered to GEC

PP = Prices published by GEC for purchase during other than hydro spill conditions

c) GEC shall not be obligated to accept or pay for and may require Seller with a facility with a nameplate rating of one megawatt or greater to interrupt or reduce deliveries of as-delivered capacity and energy during periods when purchases under this Agreement would result in costs greater than those which GEC would incur if it did not make such purchases but instead generated an equivalent amount of energy itself.

d) Whenever possible, GEC shall give Seller reasonable notice of the possibility that interruption or reduction of deliveries under subsections (a) or (c), above, may be required GEC shall give Seller notice of general periods when hydro spill conditions are anticipated, and shall give Seller as much advance notice as practical of any specific hydro spill period and the hydro savings price which will be applicable during such period Before interrupting or reducing deliveries under subsection (c), above, and before invoking hydro savings prices under subsection (b) above, GEC shall take reasonable steps to make economy sales, while the surplus energy condition exists Seller shall be paid at the economy sales price obtained by GEC in lieu of the otherwise applicable prices.

e) If Seller is selling net energy output to GEC and simultaneously purchasing its electrical needs from GEC, energy curtailed pursuant to subsections (b) or (c) above shall not be used by seller to meet its electrical needs. When Seller elects not to sell energy to GEC at the hydro savings price pursuant to subsection (b) or when GEC curtails deliveries of energy pursuant to subsection (c), Seller shall continue to purchase all its electrical needs from GEC If Seller is selling surplus energy output to GEC, subsections (b) or (c) shall only apply to the surplus energy output being delivered to GEC, and Seller can continue to internally use that generation it has retained for its own use ·

A-9 Force majeure

a) The term *force majeure* as used herein means unforeseeable causes beyond the reasonable control of and without the fault or negligence of the party claiming *force majeure* including, but not limited to, acts of God, labour disputes, sudden actions of the elements, actions by federal, state and municipal agencies, and actions of legislative, judicial, or regulatory agencies which conflict with the terms of this Agreement

b) If either party because of *force majeure* is rendered wholly or partly unable to perform its obligations under this Agreement, that party shall be liable to whatever performance is affected by the *force majeure* to the extent so affected provided that:

- the non-performing party, within two weeks after the occurrence of the *force majeure*, gives the other party written notice describing the particulars of the occurrence,
- the suspension of performance is of no greater scope and of no longer duration than is required by the *force majeure*,
- the non-performing party uses its best efforts to remedy its inability to perform (this subsection shall not require the settlement of any strike, walkout, lockout, or other labour dispute on terms which, in the sole judgement of the party involved in the dispute, are contrary to its interest It is understood and agreed that the settlement of strikes, walkouts, lockouts or other labour disputes shall be at the sole discretion of the party having the difficulty), and
- when the non-performing party is able to resume performance of its obligations under this Agreement, that party shall give other party written notice to that effect.

c) In the event a party is unable to perform due to legislative, judicial, or regulatory agency action, this Agreement shall be renegotiated to comply with the legal change which caused the non-performance

A-10 Indemnity

Each party as indemnitor shall save harmless and indemnify the other party and the directors, officers, and employees of such other party against and from any and all loss and liability for injuries to persons including employees of either party, and property damages, including property of either party, resulting from or arising out of (a) the engineering, design, construction, maintenance, or operation of or (2) the making of replacements, additions, or betterment to, the indemnitor's facilities. This indemnity and save harmless provision shall apply notwithstanding the active or passive negligence of the indemnitee.

Neither party shall be indemnified here under for liability or loss resulting from sole negligence or willful misconduct. The indemnitor shall, on the other party's request, defend any suit asserting a claim covered by this indemnity and shall pay all costs, including reasonable attorney fees, that may be incurred by the other party in enforcing this indemnity.

A-11 Liability; dedication

(a) Nothing in this Agreement shall create any duty to, any standard of care with reference to, or any liability to any person not a party to it. Neither party shall be liable to the other party for consequential damages.

(b) Each party shall be responsible for protecting its facilities from possible damage by reason of electrical disturbances or faults caused by the operation, faulty operation, or non-operation of the other party's facilities, and such other party shall not be liable for any such damages so caused

(c) No undertaking by one party to the other under any provision of this Agreement shall constitute the dedication of that party's system or any portion thereof to the other party or to the public nor affect the status of GEC as an independent public utility corporation or Seller as an independent individual or entity and not a public utility.

A-12 Several obligations

Except where specifically stated in this Agreement to be otherwise, the duties, obligations and liabilities of the parties are intended to be several and not joint or collective Nothing contained in this Agreement shall ever be construed to create an association, trust, partnership, or joint venture or impose a trust or partnership duty, obligation, or liability on or with regard to either party. Each party shall be liable individually and severally for its own obligations under this agreement.

A-13 Non-waiver

Failure to enforce any right or obligation by either party with respect to any matter arising in connection with this Agreement shall not constitute a waiver as to that matter or any other matter

A-14 Assignment

Neither party shall voluntarily assign its rights nor delegate its duties under this Agreement, or any part of such rights or duties, without the written consent of the other party, except in connection with the sale or merger of a substantial portion of its properties. Any such assignment or delegation made without such written consent shall be null and void Consent of assignment will not be withheld unreasonably Such assignment shall include, unless otherwise specified therein, all of Seller's rights to any refunds which might become due under this Agreement.

A-15 Captions

All indexes, titles, subject headings, section titles, and similar items are provided for the purpose of reference and convenience and are not intended to affect the meaning of the contents or scope of this Agreement

A-16 Choice of laws

This Agreement shall be interpreted in accordance with the laws of Guyana, excluding any choice of rules which may direct the application of the laws of another jurisdiction.

A-17 Governmental jurisdiction and authorization

Seller shall obtain any governmental authorization and permit required for the construction and operation of the Facility. Seller shall reimburse GEC for any and all losses, damages, claims, penalties, or liability it incurs as a result of Seller's failure to obtain or maintain such authorizations and permits.

A-18 Notices

Any notice, demand, or request required or permitted to be given by either party to the other, and any instrument required or permitted to be tendered or delivered by either party to the other, shall be in writing and so given tendered, or delivered, as the case may be, by depositing the same in any Guyanese post office with postage prepaid for transmission by certified mail, return receipt requested, addressed to the party, or personally delivered to the party, at the address in Article 4 of this Agreement. Changes to such designation may be made by notice similarly given

A-19 Insurance

A-19 1 General liability coverage

a) Seller shall maintain during the performance hereof, general liability insurance[3] of not less that $1 000 000

b) General liability insurance shall include coverage for premises—operations, owners and contractors, products/completed operations, hazard, explosion, collapse, underground, contractual liability, and Board form property damage including completed operations.

c) Such insurance, by endorsement to the policy(ies), shall include GEC as an additional insured if the facility is over 100 kV insofar as work performed by Seller for GEC is concerned, shall contain a severability of interest clause, shall provide that GEC shall not by reason of its inclusion as an additional insured incur liability to the insurance carrier for payment of premium for such insurance, and shall provide for 30 days' written notice to GEC prior to cancellation, termination, alteration, or material change of such insurance

[3] Governmental agencies which have an established record of self insurance may provide the required insurance through self insurance.

A-19 2 Additional insurance provisions

a) Evidence of coverage described above in section A-19 1 shall state that coverage provided is primary and is not excess to or contributing with any insurance or self-insurance maintained by GEC.

b) GEC shall have the right to inspect or obtain a copy of the original policy(ies) of insurance.

c) Seller shall furnish the required certificates and endorsements to GEC prior to commencement of operation

d) All insurance certificates,[4] endorsements, cancellations, terminations, alterations, and material changes of such insurance shall be issued and submitted to the following

GEC
Main Street
Georgetown, Guyana

[4] A governmental agency qualifying to maintain self insurance should provide a statement of self insurance

Appendix B

Energy prices

Energy prices effective 1 January 1991

The energy purchase price calculations which will apply to energy deliveries determined from meter readings taken from 1 January 1991 and onward are as follows:

Time period	(a) Incremental energy rate[5] (BTU/kWh)	(b) Cost of energy[6] ($/10 BTU)	(c) Revenue requirement for cash working capital[7] ($/kWh)	(d) Energy purchase price[8] (d) = [(a) × (b)]+c ($/kWh)
1 January				
Time of delivery basis				
On-peak				
Partial-peak				
Off-peak				
Seasonal Average (Period B)				

[5] Incremental energy rates (BTU/kWh) are derived from GEC's marginal energy costs (which include variable operating and maintenance expense) They are based on natural gas as the incremental fuel and weighted average hydroelectric power conditions

[6] Cost of natural gas

[7] Revenue requirement for cash working capital

[8] Energy purchase price = (Incremental energy rate × cost of energy) + revenue requirement for cash working capital The energy purchase price excludes the applicable energy line loss adjustment factors However, this figure is currently 1 0 for transmission and primary distribution loss adjustments and is equal to marginal cost line loss adjustment factors for the secondary distribution voltage level These factors may be changed by GEC in the future The currently applicable energy loss adjustment factors are shown in Table C

Table B[9] Time periods

	Monday through Friday	Saturdays[10]	Sundays and Holidays
Seasonal period A			
On-peak			
Partial-peak			
Off-peak			
Seasonal period B			
On-peak			
Partial-peak			
Off-peak			

Table C Energy loss adjustment factors[11]

	Transmission and distribution	Primary	Secondary distribution
Seasonal period A			
On-peak			
Partial-peak			
Off-peak			
Seasonal period B			
On-peak			
Partial-peak			
Off-peak			

[9] This table is subject to change to accord with on-peak, partial-peak, and off-peak periods as defined in GEC's own rate schedules for the sale of electricity to it's large industrial customers

[10] The applicable energy loss adjustment factors may be revised

[11] The applicable energy loss adjustment factors may be revised

Appendix C

Purchase price for as-delivered capacity from qualifying facilities for 1991

For facilities with time-of-day delivery metering and from which GEC is contractually obligated to purchase as-delivered capacity at its annually published as-delivered capacity price, the as-delivered capacity payment for power delivered by the facility to GEC and accepted by GEC is based on 100% of the shortage value of such power. The payment will be made at a rate which will vary by time of delivery and will be made for each kWh produced and delivered by the facility. The as-delivered capacity purchase price is shown on Table C as a function of the interconnection voltage, and is the product of three factors

The current shortage cost in each year the facility is operating

Currently, this shortage cost $_______ per kW-year, is the product of the annualized gas turbine cost and the Energy Reliability Index (ERI) adjustment factor The basis for the shortage cost may be revised from time to time.

A capacity loss adjustment factor

The current shortage cost is adjusted for the effect of the deliveries on GEC's transmission and distribution losses based on the Seller's interconnection voltage level. The applicable capacity loss adjustment factors for non-remote[12] facilities are presented in Table A. Capacity loss adjustment factors for remote facilities shall be calculated individually

Allocation factor

This accounts for the different values of as-delivered capacity in different time periods, and converts dollars per kW-year to cents per kWh The allocation factors are presented in Table B The time periods to which they apply are shown in Table B, Appendix B

For facilities without time-of-delivery metering, the price paid for as-delivered capacity shall be 50% of the current shortage cost multiplied by a capacity loss adjustment factor and multiplied by a weighted average allocation factor

[12] As defined by GEC

Table A

Capacity loss adjustment factors[13] for non-remote facilities

Voltage level	Loss adjustment factors
Transmission	
Primary distribution	
Secondary distribution	

Table B

Allocation factors for as delivered capacity[14]

With time-of-delivery metering	on-peak (c-yr/$-hr)	partial peak (c-yr/$-hr)	off-peak (c-yr/$-hr)
Seasonal period A			
Seasonal period B			
Without time of delivery metering	Weighted average (c-yr/$-hr)		
Seasonal period A			
Seasonal period B			

Table C

Purchase price for as-delivered capacity from non-remote[15] qualifying facilities [The product of the current shortage cost, the capacity loss adjustment factor, and the allocation factor]

Metering	Transmission voltage		Primary distribution voltage		Secondary distribution voltage	
	Seasonal period A	Seasonal period B	Seasonal period A	Seasonal period B	Seasonal period A	Seasonal period B
	c/kWh)	c/kWh)	c/kWh)	c/kWh)	c/kWh)	c/kWh)
With time of delivery						
On-peak						
Partial-peak						
Off-peak						
Without time of delivery						
Weighted average						

[13] The capacity loss adjustment factors for non-remote facilities are subject to change pursuant to orders of GEC The capacity loss adjustment factors for remote facilities are determined individually

[14] The units for the allocation factor, c-yr/$-hr, are derived from the conversion of $/kW-yr into c/kWh as follows

$$\frac{\text{c/kWh}}{\text{\$/kW-yr}} = \frac{\text{c/k-W-hr}}{\text{\$/kW-yr}} = \frac{\text{c-yr}}{\text{\$-yr}}$$

The allocation factors are subject to change from time to time

[15] As defined by GEC

Appendix D

D-1 Interconnection tariffs
D-2 Point of delivery location sketch
D-3 Interconnection facilities for which seller is responsible

D-1 Interconnection tariffs
(The applicable tariffs in effect at the time of execution of this agreement shall be attached).

D-2 Point of delivery location sketch

D-3 Interconnection facilities for which seller is responsible

Inaugural Session

Opening remarks

Navin Chandarpal Advisor to the President on Science and technology Georgetown Guyana

Thank you very much, Mr Chairman, Honorable Prime Minister, His Excellency Mr Narendra Kumar, High Commissioner of India to Guyana, other members of the Diplomatic Corps, Dr Pachauri, Dr De Groot, other participants of this Cogeneration Workshop

It is for me a great pleasure to give the opening remarks at this biomass-based cogeneration workshop which, we will recognize, has been in the making for probably three years. I am very happy therefore, that it has finally been realized and Dr Pachauri and his team are able to be with us for this exercise The timing of this workshop, though overdue, is still crucial in the plans that are being made for the energy sector in this country The Tata Energy Research Institute has been in contact with us for quite some time and also at the level of the Commonwealth Science Council which is funding this exercise, we have been looking at the necessity to hold this workshop here

In the programme that is planned for this exercise, a wide range of issues related to cogeneration are included We will be looking at the economics of cogeneration and its relevance to the economics of our country at this time, the technology of cogeneration, and institutional aspects related to this process. These are all important because very often we might be attracted by a given technology, we might see the usefulness of it, especially from an environmental point of view, but then when final decision making has to take place, we find that the economics of it doesn't allow us Therefore, I think that a good look at the economics involved in cogeneration will help in the process of our decision making The technology in today's world keeps improving and it would have impact on the economics of it, too But I think that we could not have a better team than Dr Pachauri and his colleagues here to lead us in this direction, because TERI has established for itself a name and a reputation that no one can deny Worldwide, they have been of assistance to the process of developing alternate energy system in many countries of the world I am happy therefore, that we can have them to lead us in this discussion

Also, we will be looking at the institutional aspects and this is important because we have a situation where a number of different agencies and institutions will all have to be involved The way in which the bodies which generate the waste are governed are also important That will have a great impact on the extent to which the waste that is needed can be made available for the process of energy production Also, the institutions which have to be at the buying end, because they have to look at it in the context of the economics of the running of their organization is important Then there are a number of bodies which will have to be involved in the technical process So, an examination of the linkages between these institutions, especially in the context when some decisions have to be made centrally on the state and future of some institutions, should also be properly considered.

I am sure therefore, that this exercise will be one that will be of great value to the energy sector of our country. I am glad to see that in the participation for this workshop we have representatives of a number of different organizations and bodies including the private sector and those areas of the private sector which are involved in the process which produce the waste that will be necessary and I recognize also in the person of Mr Beni Sankar one of the practical examples of the utilization of waste and that experience would be of great benefit to us.

So, I would like to thank the Commonwealth Science Council for the financing this workshop, TERI for having their personnel here, and the Guyana Natural Resources Agency/Guyana National Energy Authority for their efforts in bringing about this workshop Finally, I would like to say that all of you who are here representing various agencies have found it possible to be here and I hope the result of these three days will help to orient you better, into accepting this process of biomass-based cogeneration and that very soon we can see the results of this workshop translated in some practical way into the policy framework for energy production in our country. Thank you

Remarks

Narendra Kumar, High Commissioner, Indian High Commission Guyana

His Excellency, the acting President and Hon'ble Prime Minister of the Cooperative Republic of Guyana, Mr Samuel Hinds, Honourable Ministers of the Government, Mr Navin Chandarpal, Advisor to the President on Science and Technology, colleagues from the Diplomatic Corps, Head of the TERI, Dr R K Pachauri, the Executive Chairman of Guyana Natural Resources Agency (GNRA), Mr Joseph O'Hall, delegation, distinguished guests and friends

I am indeed honoured to be invited to the workshop on cogeneration in Guyana organized by the Government of Guyana through the GNRA in collaboration with Tata Energy Research Institute (TERI) The workshop is being funded by the Commonwealth Secretariat

Energy is the key input in all developmental activities. Fossil fuels are finite Therefore, power generation based on conventional sources cannot be sustained in the long run Conventional power generation technologies are also polluting and adversely affecting global environment and ecology

On the other hand, it is being realized that renewable energy sources can augment the availability of energy and provide a viable option in a wide range of applications The renewable energy technologies use locally available resources, are suitable for decentralized application; have low gestation, and are less capital intensive and therefore can be effectively used, both for augmenting availability of power and as a tool for rural development and social justice Therefore, there has been a growing consensus, worldwide, favouring the use of renewable energy sources as clean and sustainable source of energy This was recognized by the Government of India which established, as early as in 1982, a department exclusively to deal with the development and promotion of new and renewable sources of energy In 1992, this department was replaced by the Ministry of Non-conventional Energy Sources (MNES)

TERI, a non-profit organization, is actively involved in research activities as well as information dissemination on various aspects of economy TERI provides technical assistance services on renewable energy sources through its highly specialized experts in the field Also, there is a new organization for innovation called Development Activities Action for Sustainable Development Needs which focuses on new kinds of technology, new types of institutions, and new ways of thinking Development Alternatives is an organization set up for designing innovations and implementing them

Similarly, the subject matter is handled by the GNRA, a department of the Government of Guyana Broad objectives of these organizations concerning the renewable sources of energy could be put in three phases

- Promoting research, development, demonstration, dissemination, and popularization of new and renewable energy techniques for harnessing sun, wind, biomass, and ocean sources. Assessment of renewable energy resources potential for different areas of the country to know which source is available, where, at what cost, and to what extent.
- Promoting the creation of institutional, implementing and monitoring information infrastructure for research and development, training and dissemination of various renewable energy technologies.
- International cooperation in cogeneration is of vital importance Coordination between various organizations, institutions for project formulation for bilateral and multilateral cooperation and their processing, preparation of memorandum of understanding (MOU), agreements and encouraging, and facilitating joint ventures in private and public sector. Development of human resources in the field on non-conventional energy will form an important part of the deliberations of this workshop.

India is leading in the global renewable energy movement. Vigorous efforts are made for cooperation with developed as well as developing countries in different fields of renewable energy for foreign investment, technology transfer, and joint ventures. MOUs have been signed with Philippines, Russia, China, and South Africa. Recently, steps have been taken for cooperation with Israel, Germany, Denmark, Cuba, Netherlands, and Maldives Multilateral cooperation to United Nations Development Programme, and Global Environment Facility technical assisted projects have commenced recently, as a means of reducing emission of greenhouse gases, optimizing development on small hydro resources in the Himalayan and Southern Himalayan regions of India

At the bilateral level, cooperation has taken place in the following a 10 kW solar photovoltaic power plant sent to Cuba for the electrification of a Cuban village under the high-tech programme

Technical information on solar energy was exchanged between India and Israel There was also an exchange of personnel for higher training in the field of solar energy India wants similar cooperation and collaboration with Guyana Both the countries are grappling with problems of infrastructure and of not having adequate resources but there are abundant sunshine, wind, biomass, and other renewable energy sources which are most dependable and inexhaustible It is essential to use the non-conventional energy sources in an efficient and cost-effective way. I wish the workshop all success in its activities

Thank you very much.

Remarks

Peter de Groot, Senior Project Officer, Commonwealth Science Council

His Excellency Prime Minister, distinguished colleagues and participants

I was particularly happy when the Commonwealth Science Council was approached to assist in funding this workshop because biomass, the energy, and the potential from biomass has been an interest of mine for some time I think that it is interesting to note that most of the energy actually comes from plants, whether we are talking about fossil fuels or the food we eat. Most of our energy is the product of photosynthesis I think it is also interesting to remember that the Industrial Revolution was initially based on biomass, on wood and we only went on to the fossil fuels when the wood ran out

The last figures that I saw show that in the US there was more energy produced from biomass than from nuclear energy The so called 'wastes'—rice-husks, raw mill wastes, effluent from distilleries, and bagasse have an enormous potential for producing energy

In the 60 countries that produce sugarcane, there is a potential for something like 50 TW of energy from bagasse In Guyana, a recent study has shown that mills here can produce up to 100 MW and 30 MW from just two such stations The problems are not just technical We have experts from around the world who can solve the technical problems for producing energy from biomass The problems are more of culture and of changing attitudes It is difficult for an industry that has been producing sugar or timber or rum to think of itself as an energy producer. The challenge that I see for this workshop is to try to change some of those attitudes and to get sectors that traditionally have not been working together to start thinking along the same lines

Thank you

Address

R K Pachauri, Director, Tata Energy Research Institute

His Excellency, Mr. Sam Hinds, Prime Minister of Guyana, distinguished ladies and gentlemen It is indeed a privilege to be here on this very important occasion. Let me at the very outset introduce three of my colleagues who are here Dr Sunil Khanna, who is the Vice President of TERI, based in Washington, DC, Dr Leena Srivastava who is Dean for our Policy Analysis Division and Mr Pradeep Dadhich, who is an expert on cogeneration.

So, this little saga started at the end of 1993, when his Excellency, the President of this country visited India and we had the privilege of his presence at our institute for about two hours, during which he evinced enormous interest in all that was happening, and at the end of it, he said—why don't you come to Guyana, because we could talk of several things that could be done in my country. I took up his very kind invitation and I came here in February 1994. One of the areas that was identified for further pursuit was cogeneration using bagasse and other forms of biomass in this country We also discussed and talked about the possibility of a workshop which could result not merely in looking at what needs to be done, but actually result in some action that might make it possible for this cogeneration to become a reality

I tried for several months to get some support for organizing such a workshop and I am happy that the Commonwealth Science Council saw this as an important activity and provided support for holding this workshop

Mr Navin Chandarpal, was very kind in saying that we are here to lead everybody in this effort. I would like to submit that we are not here to lead, we are here as your collaborators, partners, and supporters In fact, the leadership exists over here, the amount of work that has been done, the amount of work that all of you have produced in showing how cogeneration could take off, is really enormous I must compliment the Guyana Natural Resources Agency and the Guyana National Energy Authority for the excellent document that they have brought out on Energy Policy I think it is right on target Of course, one runs into enormous problems of implementation where we would be very happy to share our experiences in similar situations, and be of whatever little assistance we can

I just want to briefly mention the role and the activities of the Tata Energy Research Institute. We are a non-profit research institute. We have a total strength of about 450 and we raise most of our resources through our own efforts. Therefore, we are in every sense financially autonomous. We have an enormous global outreach, we've got an affiliate institute, called the Tata Energy and Resources Institute established in Washington, DC, and we were privileged to have the then senator of the US and current Vice-President Al Gore as our Chief Guest, when that institute was launched. We also have a presence in Germany and Thailand and we are the centre of a network of 23 different institutions around the world that research together on energy and environment issues. I might also mention that our major area of expertise is in biomass as in this

country. For this purpose, we have a major biotechnology activity which permits us to accelerate the growth of biomass and increase its yields and productivity right through the stages of conversion, production, and utilization. In conversion, I will give one example—the enormous amount of rice-straw that's produced in this country can be utilized to produce methane or biogas through microbial cultures that we are working on through our biotechnology activities.

Finally, I'd like to mention that having gone around this country, we are very enthusiastic about what is happening and the enormous changes taking place here When one looks at the infrastructure, and the natural resources in this country, it has all the makings of a middle income country and I am sure that this is where it is going to go in the next few years with the leadership that the country is getting today. And in this effort, I might also mention, we as your partners would be very happy to work with international organizations, whether it is the Industrial Development Bank or the United Nations Development Programme (UNDP) I am presently an Advisor to the Administrator of UNDP and we also have a very close relationship with Global Environment Facility (GEF) There would be possibilities for mobilizing support from GEF. I just want to end by assuring you, that we are very excited at the prospect of this workshop, which I think marks the beginning rather than the culmination of a partnership that we see extending over many years

Thank you very much.

Feature address

Hon'ble Samuel Hinds, Prime Minister, Guyana

Thank you very much, Chairman O'Lall, members of the headtable, Dr Pachauri, my friend Navin, Commissioner Kumar, Dr Peter De Groot and Mr Bender, members of the Diplomatic Corps, special invites, participants, distinguished ladies and gentlemen

A reliable supply of energy, particularly electricity, at the best possible and sustainable price is essential for modern living, economic, industrial and commercial activities; and comfortable domestic living The ongoing availability of basic energy is a strategic issue The cost is also significant For a country like Guyana—where energy is obtained largely from imported petroleum products—the foreign exchange outflow is always pointed to The large potential of our local energy sources is also before us If we could switch to these, the utilization of foreign exchange for energy could be greatly reduced. The local economy would receive a big boost and employment could be increased. The idea is very attractive, but how can one achieve it?

Even if petroleum products are still strong in the market, to go against the market is often very demanding and inevitably questions of subsidies and incentives arise. Much concern about energy was caused by the oil shocks of the mid-1970s when unimaginable increases in the petroleum prices were announced by the Organization of Petroleum Exporting Countries (OPEC). Adequate research and efforts were put into energy conservation, and substitution of petroleum products by natural gas, coal, wood, and biomass There was much consideration of energy forms, utilization of sunlight, wind, waves, ocean thermal gradient, geysers, etc. While, little seems to have come directly from all this activity, it was not in vain Crude oil prices which were expected to rise up to US $35 per barrel, did not do so. Over the last year, prices have been of the order of US $20 per barrel or less

I think that the extent to which the rise in oil prices has been constrained could be seen as a success for programmes and activities of the latter part of the 1970s and the 1980s But at the same time, the fact that oil prices did not rise significantly also meant that a lot of the projects which were undertaken were no longer economic. While many of them were shelved, others fell through In fact, I think that in our last search for power supply for Guyana Electricity Corporation (GEC), one of the units being offered was a unit built as a demonstration unit, towards the end of the 1970s to utilize all sorts of solid material to produce power.

Let me list out a few of the local alternatives and possible local programmes which have attracted significant attention. First of all there is the question of the greater utilization of bagasse at ugar estates I remember the paper delivered at a GAPE meeting towards the end of the 1960s by Mr Burkett on 'Energy Considerations on a Sugar Estate' and the design philosophy at the time was to find the pressure at which the factory or the boilers would be run, to satisfy the requirements. The first requirement was to bring about incineration of all bagasse without requiring supplemental wood supplies or minimizing supplemental wood supplies. We wanted to

have a zero situation with respect to bagasse, and there was the requirement to meet all the steam and electrical needs and the conditions of those times gave an answer for boiler pressure in the range of may be 150–180 psig.

These days, to consider maximizing the output of electrical energy from the sugar estates, thinking of the sugar estate as a two-product enterprise, is attractive One of the schemes that seems to be favoured at this time has the following outline: gas would be burnt in boilers, producing steam at much higher pressures of the order of 900 psig This steam is first fed to a 60 Hz generating system to feed the grid and then sufficient steam is bled off at current factory pressure to run another existing 50 Hz generating set and to meet existing steam requirements Continuous improvement in energy utilization in the factories is maintained to minimize their use of electricity and steam. An amount like 100 MW may be possible out of bagasse, 30 MW in all the factories if they minimize their use, and 70 MW made available for export

There has been a lack of progress in this area. This is attributed from time to time to Guyana Sugar Company (GUYSUCO) or Guyana Electricity Corporation (GEC) or both But I am cautious about attributing any blame, as I know that many of the marginal programmes sponsored by first rises in oil prices were aborted due to end losses We consider that switching to bagasse is only attractive where crude oil is available at more than US $25 per barrel

There are other problems in seeking to maximize energy from bagasse We must recognize that a lot of them have to deal with the future of the sugar industry and the factories themselves. There are arguments for consolidation of factories from the current eight down to as few as one, although keeping all eight for the foreseeable future seems to be the main one In the past, there have been discussions about consolidation of factories, and there are advantages in doing so even for making those high-pressure boiler systems more attractive There is also the fact that bagasse is only dependently available for eight months of the year, so it introduces issues of 2-fuel systems if electricity is to be depended on and at this time GEC needs a very dependable base-load power and not just a situation where it could shut down equipment and take power that happens to be available at a price below the running cost. GEC's need for greater dependability and assurance at this time puts a limit to the kind of power that it would want to get into a contractual situation with

I notice that a feature of the workshop is on cogeneration which is trying to bring together and satisfy the needs for heating as well as for electricity. This has been practiced in the sugar factories as well as the alumina plant at Linden and focusing on cogeneration seems to say that we should be on the lookout for industrial developments which may need significant amounts of heat like drying wood, processing agricultural and food products and then look to see how we could bring together often in the same physical place at the same plant site, those heat utilizing factories, enterprises and electricity generation. The paper recycling plant being built by SAPIL is one such candidate and some consideration was given to the possible setting up of the 20 MW plant for the GEC at that site but the advantages of having it at Kingston were overwhelming. Industrial sites, where there would be an electricity generating unit and the heat absorbing plants, could be developed The focus should also be on conservation of energy in every area that it is used—cooking, air-conditioning, and lighting There is potential in reducing the amount of energy utilized Many may require changes in habit and in culture Others require more or less costly changes of equipment. The utilization of waste of rice factories, sawmills, and

garbage always appear attractive Projects utilizing such sources need to be thoroughly studied in detail.

There are various ways of utilizing biomass by direct burning, producing some form of charcoal, carbonizing, gasifying, and in special cases, producing liquid products. There is also conversion of vegetable material and fermentation to produce alcohol and methane.

At the time of the first oil shock, many of the various institutions observing the extensive nature of forests in Guyana suggested energy farms to produce wood and charcoal for direct consumption or for feeding gasification systems.

Solar and wind in Guyana are being looked at I was particularly interested at one time when I heard that making the Iwokrama Base Camp totally photovoltaic was being considered. Since then I hear that there are possible problems in the way and I think that a great opportunity would be lost.

It has been, for us Guyanese, a matter of great longing, patience as well as frustration to see hydro-electricity developed in Guyana and we have about 69 potential sites identified One of the problems here has been to match a site with our relatively low demand on the coastal area here, 100 MW and the transmission costs I have also recently been excited by a proposal to develop the Tumatamari site as a low head, run-of-river site that was not maximizing the potential flow The potential hydro-electricity from the site over a year would however supply enough to nearby Omai and that appears to break the ice for hydro-electric development in Guyana

This workshop is intended to discuss and resolve some of these questions This government, desires the examination of all power supplies options and the promotion of cost-effective ones. This workshop will focus on the utilization of biomass—bagasse primarily—but also rice-husk, wood wastes, and wood.

I wish you all success in your deliberations. We have seen attempts to break away from petroleum products in Guyana and I would like to mention three of them In the early 1970s, UMDA, the large development in the Mazaruni where we spent around US $100 million of our own Guyanese money earned from windfalls in sugar

We were attracted to the very large hydro-site to get low unit costs of production of electricity, but it needed large amounts of investment in the industries to utilize the hydro-electricity. We lost about US $100 million and even more costly to us is the fact that it more or less created an era where GEC was almost abandoned and forgotten.

Thirdly, we have at Demerara Woods Ltd the choice of wood-gassification units to produce power there. It would be of the order of 10 MW and the gasifiers themselves were the problem. I was hoping that I may be able to tempt the gentlemen from India and the one from the wood grain company to offer a gasifying unit that may run with those engines and generation sets.

I wish you better success than the past generation and it gives me great pleasure to declare this workshop open.

Session I

Cogeneration: potential and economics

Vote of thanks

Mark Bender, Chief Executive Officer, Guyana National Energy Authority

Thank you very much, Mr O'Lall. It is my pleasant duty to say thank you to a few people who have assisted in the planning process of this workshop. But before that, I would like to say our heartfelt thanks to the Honourable Prime Minister for gracing us with his presence here today. He gave a very analytical and informative presentation He put the whole question of the drive towards renewable energy in its historical context, going back to the period of the early 1970s, when the dramatic increases in oil prices forced people in that direction, but he also mentioned the fact that before going into the use of renewables, one should check their cost-effectiveness.

I will also take this opportunity to say thanks to Mr Navin Chandarpal, who is the person responsible for energy and has been a source of great inspiration to all of us who work day-to-day on national energy management issues. As Mr O'Lall mentioned, he was the driving force behind the preparation of the National Energy Policy and he gave a very informative presentation. He too made mention of the economics of cogeneration. Unless things prove to be cost-effective, regardless of the realities of physics, chemistry, and natural phenomena, things don't get done

We are grateful to the Commonwealth Science Council and the Secretariat for providing a majority of the funding for this seminar and to ask Dr De Groot to pass on our thanks and best wishes to Dr Nevelliw Trotz who is the head of the Secretariat.

To the High Commissioner of India, Mr Narendra Kumar His presentation was very analytical and very informative He put the whole question of the renewables into a context We also want to thank him for his offer of further assistance in this field from the government and the people of India, we will certainly be taking up your challenge. Thank you very much, Mr Kumar.

To Dr Pachauri, for gracing us with his presence and it is extremely important for me to say that Tata Energy Research Institute (TERI) has played a very important role in this workshop It was their initiative, as a consequence of a workshop they had a couple of years ago, when they came here at the invitation of the President of this country. We are deeply thankful to TERI for this. They have played a very important role not only in terms of the resource persons they have managed to organize to give the presentations here today but also in the logistics and organizing of this workshop and in this regard I would take this opportunity to give my own special thanks to Dr Sunil Khanna who has been working closely with us in the Guyana Natural Resources Agency (GNRA) and the Guyana National Energy Authority (GNEA) to ensure that all the arrangements for this workshop are in place

I just want to say thanks to some local organizations who assisted us in this exercise To get a feel of any particular phenomena one should see the activity and have a practical insight into how this thing works in a particular environment and we seized the opportunity to take the overseas

resource persons who are here to some facilities in Guyana to let them get the feel of what is happening in Guyana with regard to biomass for the purpose of cogeneration and generation of steam and electricity They were taken to the Kayman Sankar facility at Blairmont and the Blairmont Sugar Estate. I would like to thank Mr Benu Sankar and his officers at Kayman Sankar Investment Ltd and the personnel at Guyana Sugar Company's estate at Blairmont, in particular Mr Bart and Mr Navin Parsad who made this possible.

I would also like to thank the Guyana Forestry Commission, particularly the Commissioner who is here, for assisting us greatly with the provision of a minibus for the transportation of the overseas resource persons from the airport

We would also like to thank Hotel Town for making the arrangements here today and providing all the facilities for this workshop.

I would also like to thank the members of our staff at GNRA and GNEA who worked assiduously to ensure that the logistics of this workshop were in place and in particular I would like to mention Ms Albena Willburg, our office Manager, Mrs Sobitha Subryan, who is Mr O'Lall's secretary, Ms Audy Clarke, my own secretary, Ms Angela Bryan, Ms Patricia Joseph, Ms Minerva Devonish, Mr Troy Williams, Mr Nelville Duncan, and also Mr Raymond Dundee and Mr Doorga Prasad, two of the Directors of units under the GNRA. They all played their part in ensuring that the local arrangements were put in place

I would like to thank Dr Khanna and Dr De Groot, whose presence here for the past two or three weeks has been very supportive of our efforts

Finally, I would like to thank the people for participating in this workshop and accepting our invitation

So, on behalf of the GNRA and the GNEA, I would like to say, once again, thanks to all concerned

Introduction to cogeneration and benefits of cogeneration

R K Pachauri, Director, Tata Energy Research Institute

What would be a far more productive use of time would be a discussion on actions that need to be taken and how to move further. Some of the benefits, largely to serve as a reminder, and also to point to some specific benefits that are of a larger dimension arising out of cogeneration activities that very few people generally consider, are highlighted here

In its simplest definition, cogeneration is the efficient production of two forms of useful energy from the same fuel While bagasse-based cogeneration would be the focus of this workshop, this paper is not confined only to bagasse cogeneration because there are other opportunities which cover other forms of biomass as well.

One major benefit of cogeneration is the fact that it gives decentralized options for producing and utilizing energy and while, if one looks at the experience of most developed countries, the approach has been, throughout the world, to pursue a sort of a single path or pattern of development where there are centralized forms of energy production and this certainly calls for a certain infrastructure which has produced economic growth in most of the countries of the north but it is not necessary that the same pattern of development be adopted and followed. It is now increasingly clear that there are some merits to decentralized production of energy and therefore the development of economic opportunities turn around those decentralized options that are far more in tune with the culture, pattern of development, and lifestyles of developing countries So the benefit of cogeneration is that it permits one a decentralized option which is obvious by the requirement of some major adjustments in the pattern of development that might be pursued

The second area of benefit is environmental, because cogeneration permits the use of fuels more efficiently to the extent that for the same unit of output lower levels of emissions and pollution are produced and is more relevant in today's context when the key path to development is sustainable development Now, in the entire negotiations that led up to the Framework Convention on Climate Change, a very vocal and effective group of small islands continuously highlighted the dangers of sea-level rising and what it may do to their entire existence. Nobody focused on this important aspect that is threatening Guyana

It would be in keeping with the options for reducing the emissions of greenhouse gases worldwide, for Guyana to develop and show these options as a model of what perhaps other parts of the world should do , but more than that, there are enormous local benefits that one needs to consider

Thirdly, cogeneration allows short gestation opportunities for producing and using energy and, in a large way, particularly in the case of hydro in the short and medium term which is the em-

phasis of this workshop and the energy policy of the country. Cogeneration provides a means by which, within the medium term, electricity can be produced to feed to the grid.

Having talked about a cogeneration project in rice milling in Thailand, on rice husk, there are some details provided about this particular project and it is only put forward as a sample. This mill has a boiler of about 17 tonnes per hour of steam at 35 bar pressure. It has a 22.5 MW double generator capacity. There is also a heat exchanger for use in paddy driers and a water chiller for cooling purposes. This is a technology which is used in this country as well. The total cost of this project was US $3.865 million. The electrical savings annually was about $ 840 000. The power sales that would fetch earnings for the company come to $ 160 000 and the heat for drying which would really replace petroleum products would be equivalent to a benefit about $ 128 000 and the rice husk also would result in some sales which would be $ 440 000.

With all this, the payback period for this project was barely 3 ½ years. and the internal rate of return was 37%. This is typical of such cogeneration projects and of the kind of economic benefit that would accrue to a company that sets up these cogeneration facilities.

Within a national context, then this would certainly be a very attractive proposition because to set up centralized power, cost per MW would be substantially higher.

For the economic benefits for this country, there is roughly a potential of about 100 MW of cogeneration that could be harnessed. The total investment required would be about $125 million approximately, give and take a few percentage points because it depends on the specific situation of the facility where cogeneration is to be installed

If the value addition potential for the country's economy is looked at, on a very rough calculation, something like $400 million annually is added through the increase of this power output from cogeneration. It is not merely something that follows demand as one sees it increasing, on the basis of current structure current capacity of economic activities, but as a means by which one would be able to attract investments because the power is going to be available and thereby increase the economic output of the country Thus, it becomes an integral part of the country's development strategy. Guyana Natural Resources Agency (GNRA) and Guyana National Energy Authority (GNEA) are emphasizing the importance of providing a scenario, a vision of increased energy output by which a number of activities which don't exist today in the economy will become realities

This could include value addition to the bauxite zones that exist, it could include value addition to a number of raw materials that are being produced currently. Even in the sugar industry, there might be opportunities for value addition. Therefore, the profitability from those investments is very high It is not merely narrow cost benefit analysis for the organizations themselves that is going to install these facilities, but the opportunity that increased power would provide for increased economic activities, to provide value addition to output that is taking place in currently

What is the key prerequisite for making this happen? A market for cogeneration has to be created and what is needed is a new contracting regime whereby that market is created. This is precisely what this workshop is hoped to achieve at the end of the three days and beyond.

The benefits of creating a market for cogeneration are not limited to cogeneration alone. Essentially what one is doing is providing a level playing ground for all forms of decentralized energy production and therefore it makes it possible for bagasse-based cogeneration to take place, which is of prime concern, but also cogeneration using rice husk in rice mills, like the example of Thailand It should be possible to create biomethanation With the large amount of rice-straw and other agricultural residues that exist in this country and with the application of biotechnology techniques it is entirely possible to develop microbial cultures that would help produce methane gas from these agricultural residues. Those in turn can be used for heating purposes or power generation or a combination of both and all it would require is a system by which the additional power which is produced and fed to the grid at a reasonable rate setting for which the cogenerator or the producer of the utilized energy can get a reasonable return.

It would also bring into existence the possibility of wind power generation. It is clear that in order to produce wind power, the first step is to carry out a wind resource assessment. Wind electricity has a very peculiar characteristic. There might be a spot that is totally unsuitable for electricity using wind and just 10 metres away there might be a spot that is suitable, that will enable one to set up a wind power generator

A large area of say, 200 sq m can be taken and it is assumed that one will be able to set up wind power systems in that entire area That may, or may not be true because there are substantial variations that occur between locations that are contiguous, very close together. But, for a contracting regime, whereby someone who invests in wind power and sells it to the grid, he/she can get a reasonable price that makes it an attractive investment.

China is a prime example of small hydro-power generation. In India there is a United Nations Development Programme/Global Environment Facility (UNDP/GEF) project on small hydro which incidentally is located within TERI, and this is a major effort to see that small hydro takes off in India There are a number of small hydro power plants but not quite to the extent that potentially exist So if there is a proper pricing regime, a proper contracting arrangement, small hydro can also become a reality

Cogeneration also permits one to bring about an overall technology upgradation in industry. In the wake of the oil crisis in 1973/1974, when world oil prices quadrupled, there was an effort all over the world, even in the developed countries to reduce energy consumption by increasing efficiency Now, in the process of improving this efficiency, factory owners also found ways by which they could revamp the entire process and the plant which produced goods and services. Therefore, energy conservation efforts gave them an opportunity to bring about several other improvements in their operations The same opportunities exist with respect to cogeneration facilities as well, because when a cogeneration facility is set up the system is revamped.

The environmental benefit from cogeneration and the fact that decentralized forms of energy production allow one to develop rural areas, outlying societies, and communities which otherwise would just move into urban locations and create the kind of problems that are seen in most of the developing countries where large cities are bursting at their seams and there are large slum populations that have come up. This point is particularly relevant because today the UN Habitat Conference is opening in Turkey and the whole problem of urbanization, the effects of urbanization, something that is linked with energy problems and how to solve them

International trends in cogeneration

Leena Srivastava, Dean, Policy Analysis Division, Tata Energy Research Institute

The centralized electricity generation has become a very attractive proposition. But, due to this there was a physical distance that was added between the location of these power plants and the demand centres themselves. Combination of these two factors had an adverse affect on cogeneration as a concept. On the other hand, in the early 1970s again there was a reversal of trends largely because of the fact that oil prices increased substantially in the early 1970s as well as the latter part of the 1970s and also because there was a diminishing marginal network to the larger generating plants that were being produced. Combined with the fact that there were significant advances in the efficiency of cogeneration plants there has been a revival of interest in cogeneration as a technology. Much more recently, the environmental benefits have played a major role and will probably play a more significant role in the years to come.

The typical application in which cogeneration systems have been utilized are district heating, residential and commercial sector, and for industrial application In the instances of countries like Guyana or India, district heating as an application is not very useful, nor is the use of cogenerated heat for commercial or residential systems. The primary application is in the industrial areas

The very intensive industrial sites have been the most common hosts of cogeneration systems and there are several reasons why this was so. The most significant of these is the fact that some of these energy intensive industries in particular had heavy thermal energy requirements, they also had stable loads with very little variations either on a daily or seasonal basis, and the fact that there were sites that were owned for power production and therefore lended themselves much more easily for the combined generation of heat and power. A fourth factor was the availability of low cost fuel sources This is true particularly in the case of biomass industries also in the instance of those industries where a lot of waste heat is generated. Another very significant factor is the fact that there are very competent operations and maintenance personnel who would be able to operate these plants much more efficiently.

The application of cogeneration in industry also becomes much more attractive if the industry itself has an energy cost reduction goal that it is pursuing and last, but not the least, there is the fact that there is a reliable grid back-up supply to back-up the cogeneration systems that industries have

In a survey that was conducted across several industries, it emerged that there are several additional incentives that would make cogenerated power or heat much more attractive. These included, but are not limited to, the clear and equitable interconnection system specifications. For electricity grids there is the need for a stable regulatory environment to have power purchase agreements that are financeable and not open ended and to have an assured power supply for cogenerated electricity

Today, there are nearly 50 000 MW of cogeneration plants that exist in the world and a very significant proportion of these are in the European countries There is a very rapid increase in demand for cogeneration, in some of the Commonwealth of Independent States (CIS) countries, and some countries in South America and Asia. An important conference was organized earlier this year, the First Annual International Conference on Cogeneration in India. This conference had attracted a lot of attention.

But despite the fact that a significant proportion of cogenerated capacity exists in the world today, this would not have been possible without substantial support from the governments of these European countries where cogeneration plants are in existence and the type of support that is offered by the various governments includes information and feasibility studies. Information is being made available by almost all the European governments, as they make up the largest percentage of the cogeneration plants; in the form of brochures, video tapes, and several other of the various programmes that they have going In addition, a number of these governments offer substantial financial incentives France and Italy for example, support and provide a subsidy equal to 50% of the cost of conducting a feasibility study for cogeneration purposes. The Netherlands also provides 50% of the valuation cost but subject to a ceiling of about 50 000 guilders Turkey promotes industrial cogeneration by financing industrial energy audits and the UK provides financial assistance for consulting services for those projects which *prima facie* show evidence of being able to save at least 10% energy by installing cogeneration plants. Several other European countries also have various information programmes and support programmes for feasibility studies.

The other support that is provided is in the form of institutional arrangements largely through pricing mechanisms and the types of institutional arrangements that governments make are where (i) prices for cogeneration power are fixed legally, (ii) prices are reviewed by various authorities that have been set up for the purpose, and (iii) prices have been based on a specific projection by a government institution on the role that cogeneration plants can play in that particular country

Direct financial incentives that some of these governments have been providing, are also quite substantial. Canada provides preferential tax treatment for capital depreciation and they allow 100% depreciation of capital over three years which is split as 25% in the first year, 50% in the second year, and 25% in the final year. Denmark provides an investment subsidy up to about 30%, France promotes cogeneration by exempting the industries or organizations that are investing in cogenerating plants from the payment of fuel taxes and providing a subsidy of about 50% of the professional tax that is applicable to such industries otherwise Japan makes available low interest loans to the companies and Sweden has a fixed subsidy per kW of installed capacity only for bio-fuels based cogeneration plants.

These are the various kinds of financial incentives that are made available by some of the European countries A sample of about five countries in terms of the share of electricity supply that cogeneration plants are meeting are presented here They are Denmark with a share in total electricity supply of about 29%, Finland with a share of about 30%, Netherlands with a share of 15%, Sweden 3 4%, and Switzerland 2 1%.

Biomass-based cogeneration: potential and economics

Pradeep Dadhich, Fellow, Tata Energy Research Institute

A lot has been said about cogeneration It is the production of two forms of energy by the utilization of one fuel There are one or two additional benefits of cogeneration which I will deal with briefly

The potential of cogeneration

The future energy prices are going to have an effect on cogeneration There is a substantial need for energy capacities and at the moment it is rising and is going to continue to rise significantly The industrial structure is still under transformation and at the moment it would depend upon the future economic activity of Guyana Industries which could contribute to cogeneration in Guyana are. sugar, rice mills, and plants which produce waste and generate substantial fuel. The technical advances that have taken place the world over have been significant and Guyana could leap frog considerably to get very high potential levels in cogenerating systems.

For a sugar mill of 5000 tonnes of crushing capacity and using a boiler of low pressure say 17 bar, the cogeneration plant would be generating 5 MW power consuming approximately 45 tonnes of bagasse. However, if a high pressure and high temperature system is adopted say using 48 bar, 400 °C, then the power generated would increase fuel If still higher pressures are adopted for cogeneration, say 63 bar and 80 bar, the power generated would increase in addition to 12 MW by 3 MW and 2 MW respectively Systems world over are now adopting 103–120 bars for bagasse combustion Higher pressure increases the Second Law of Efficiency in power generation

So, in India right now, they are operating at very low pressures initially The Sugar Mills Association has decided that minimum pressure should be around 40 bars in India, and this is also changing significantly after the initiatives taken by the Government of India to improve cogeneration, or implement cogeneration significantly in the country There are two or three plants which are coming up with 80 bar and one plant with 103 bar using bagasse as the fuel. So there is a substantial jump and increase in the capacities of power generation with the availability of the same quantity of bagasse Hence, technology can significantly make a difference for power generation as far as the potential is concerned

Based on some figures from the Energy Policy Committee in Guyana, and some of the discussions an estimate of the cogeneration potential in Guyana has been made. The biomass availability in the country at the moment as collected from discussions and the data supplied by Guyana Natural Resources Agency is equivalent to 1596 thousand barrels of oil and for rice husk it is about 20 000 metric tonnes based on the number of rice mills that are operating in the

the current market price of electricity itself. This ensures that cogenerated electricity has to be competitive with other electricity forms that are being produced. Another aspect of cogeneration in Finland is that third party sales are not allowed. This is also true in Denmark.

In India, the electricity system is a concurrent sector where decisions regarding electricity supplies are made both at the central and at the state levels. The centre is involved in planning for electricity supply, whereas the state implements it and sets tariffs for the electricity that they supply to the consumers. The role of the renewables-based electricity generation is evolving in India and very recently a great impetus has been provided to renewables-based electricity generation largely because of tremendous shortages of electricity supply and capacity in the country.

If one looks at the long-term requirements for the next 15 years, one needs to add about 7000 MW of electricity capacity a year and what has been achieved in the last Five Year Plan period is a little less than 3000 MW a year. So, every year a deficit is being added, shortages are increasing by 4000 MW a year. Now faced with this situation, the Ministry of Power which is responsible for the electricity sector adopted a much more lenient stand towards renewable electricity. The Ministry of Non-conventional Energy Sources has been established which has become very active and has put in place several policies for promoting the use of renewables in the country

One such policy relates to bagasse-based cogeneration. While there is a fairly well-defined policy for bagasse-based cogeneration in the country, very little has been done with industrial cogeneration, the potential for which is quite substantial Several studies in India have indicated that there may be a total cogeneration potential ranging from about 10 000 to 30 000 MW. But some of the policy incentives offered by the Government of India include an attractive price for cogenerated power, which the utilities are obligated to buy This holds true only for bagasse-based cogeneration, so any sugar plants that are producing electricity and have surplus electricity to sell to the grid, the state electricity where this particular plant is located, has to buy the electricity that is produced by the sugar company and has to offer an attractive price The price that was fixed in this instance was in the range of 6 5 cents per kWh

The other major policy initiative that was taken was to allow third party sales of electricity generated through bagasse-based generation and to allow the units to bank their excess electricity supplies with the utilities and withdraw it at a later point when they have a need for it.

These were some of the incentives that were provided There is still an enormous potential that remains in the country and needs to be exploited which goes beyond bagasse-based cogeneration That was the focus of a workshop held in India—to create an awareness for the potential and economics and also to sensitize policymakers to the need for exploiting this enormous potential that exists in the country. One can draw a parallel, between the situation in India and Guyana

India is like a large number of small countries put together with different economic classes, different cultures, different agro-climatic regions but particularly a very large dependence on biomass energy for meeting the energy requirements of the country

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country and the fuel wood is around 1543 barrels of oil equivalent There are other sources of heat as well as fuels available from various industries The industrial wastes that are available, still have to be quantified. Breweries and hotels produce organic wastes which are likely to provide substantial fuel

Now based on these figures, the technical potential, which is for bagasse-based cogeneration is 750 MW, for rice husk 400 MW, for saw mill waste 100–150 MW and for others, it needs to be determined. It roughly comes to 1250 MW potential that is existing This is not the economic potential as it is based on the total fuel availability in the country and there is going to be significant reduction in the available power which is economical

As far as local site aspects are concerned there are three major points which can affect the cost of generation; (i) that some of the industries like the rice mills and the sugar mills, are totally dependent on their own power, (ii) these industries do not purchase backup power from GEC as they have a standby power generating station, and (iii) the total cost of conventional power that is available and the cost of fuel to the cogenerated power in biomass and in the waste generating industry is considered. The cost of fuel is taken as zero because it is self generated But it has a significant potential as far as economics is concerned to supply to the grid. Then if a cogeneration system and the heat demand in the process matches with the amount of power that is generated through steam expansions in the turbine, then the cost of power generation would decrease substantially However, if power is generated through the condenser then the cost of power generation would increase

In India, the opportunity cost of the fuel would be considered If the fuel was to be sold in the market, what would be its cost. The fuel is bagasse in this case What it would cost to sell or dispose it of. That would be taken as an input cost for power generation So for calculations of economics the opportunity cost for the quantities that have been indicated are considered and they are based on estimates

Session II

Relevance of cogeneration to Guyana

Current energy situation: demand and supply issues, status of the power sector—part I

R K Pachauri, Director, Tata Energy Research Institute

Thank you, Mr Chairman, I am really not going to say very much on demand and supply projections, because that is a task which is being done so well by the Energy Committee. What I would like to do is to look back in retrospect at some work that I became familiar with almost 17 years ago. I'd brought out a book based on a set of papers that were presented. The title of the book is *International Energy Studies* and in it is a chapter on 'Alternative Energy Sources in Guyana' by A M B Sankies

Just to give you an example, and in support of what Mr O'Lall has said in discussing biomass and industrial alcohol, I will quote from the paper. It says:

> power alcohol was produced in Guyana in the 1920s and according to historian, W H L Payne, the Colonial Secretary pointed out to the Governor in 1922, 'the Government also considered that if the experiment succeeded, it would assist the Colony in becoming independent of other countries for fuel supplies for internal combustion engines, and that if mechanical tillage were to be employed to a greater extent in the Colony, there must be a cheap and readily obtainable supply of fuel for operating tractors, pumping engines, etc. .'

This was way back in 1922, and what was said then is valid today. Based on this, a decision was taken to recognize the role of power alcohol in agricultural development. There are figures presented on the actual production of ethyl alcohol and denatured alcohol from 1921–28 But there is also a statement here which says that production ceased by around 1932 due to a decision of the sugar producers to produce sugar only So I am only raising something which has already been articulated by Mr O'Lall on the enormous opportunities available for using sugarcane and its products, not necessarily for sugar production, but for a variety of other purposes All of these need to be evaluated in terms of the economic and other benefits

Another interesting point that I would like to bring to your attention refers to what the Honorable Prime Minister raised this morning He talked about using fuelwood through the route of charcoal and other such possibilities. The production of charcoal in 1965 was 2450 tonnes and this had declined to 211 tonnes in 1974. The other interesting point that he makes, is that the figures given by the Charcoal Unit of the University of Guyana, National Science Research Council, indicate that about 60 million coconuts are produced yearly, representing a total of 10160 tonnes of shell, based on an average fresh weight of 180 g per shell. The estimate was that carbonization of the 10160 tonnes of shell would yield significant tonnage of charcoal This again represents a very interesting resource

Looking at the demand and supply position in Guyana, I would like to focus on the sectoral use of energy as it emerged in 1988 and 1992. The electricity sector took upwards of 20%, the min-

ing industry is still the largest user of energy, at 30% plus, transportation is around 10% or so, and residential is around 25%. It appears that these shares would continue on the same trend, except in respect of any new investments that might take place that could alter the structure of the economy in the country. I'd like to emphasize the point that is often missed in looking at demand and supply scenarios. The demand for energy is basically a derived demand. In other words, energy is demanded as an input of the production or consumption processes. So, if transportation activity increases the demand for energy goes up, depending on the technologies of transportation . Likewise, if industrial activity is increased the same thing happens

So, it is important to remember that the demand for the future is going to be determined essentially by the mix of production and consumption activities that will take place in the economy.

And, therefore, one might repeat what is usually referred to as the Law of Demand in Economics and this law states that demand will increase to meet supply. This is particularly true in the case of electricity. If you produce power, then power becomes a very attractive input of production which in itself will give impetus to the mobilization of investments of new capacity to produce goods and services. Therefore, if one is looking at future policy then one needs to look at it in an integrated fashion whereby energy decisions are taken concomitantly with economic decisions to diversify, expand, and improve the economy of the country.

Electricity generation for 1992 can be broken down into bagasse 400 × 10^3 barrels of oil equivalent (boe); fuelwood, 40 × 10^3 boe, petroleum products, 1069 × 10^3 boe. If we look at energy supply in each sector, transportation essentially uses petroleum products; industry and mining use bagasse, fuelwood, petroleum products, and electricity The residential sector largely uses fuelwood, and petroleum products; and agriculture and fishing again largely use petroleum products.

So, looking at this energy balance if one was to move in the direction of the desired energy policy, then clearly the following sets of objectives will have to be met Firstly, displacement of petroleum products as a source of energy That would only happen if, you have a change in the technology and the structure of a particular sector that uses petroleum products In other words, if there are boilers that are using petroleum products, those would have to be converted to be compatible with other fuels which would require certain investments and market signals. Secondly, you will have to create capacity for supply simultaneously, whereby those alternative fuels can be made available for this changeover. I'd only like to emphasize that we are dealing with a complex set of issues where isolated decisions in one sector of the economy are not really going to help unless one takes matching decisions in the other sectors of the economy.

Now, I am not aware of the facts in the case, but what the Honorable Prime Minister said this morning about US$ 100 million in the development of energy from hydro almost 20 years ago or more is a case in point Where an isolated investment decision in one sector of the economy can prove totally infructuous unless there are matching investments in other sectors of the economy And, given the fact that the government is not responsible for these investments directly from government funds, the only way to devise the right set of responses and encourage the right set of investments taking place would be through providing market signals. What we need to do, since we are concentrating on the short- and medium-term, is cogeneration We have to devise market signals and a set of policies by which investments in cogeneration will take place, so that the resources that are currently being utilized inefficiently will be utilized more efficiently in the future.

I was struck by Prof Sankies' premise for projecting the capacity for power generation in the country up to the year 1995, which was based on the development of the economy, in the same manner that is being considered by today's policymakers

Now, of course, it is another matter that what was projected as the capacity at that point of time has not materialized, and we know the reasons why it has not materialized But it is important to realize that there is a certain degree of conviction that one can get from the fact that these issues and the approaches considered earlier are as valid today as they were sixteen years ago

In our discussions yesterday, Mr O'Lall mentioned that in a country of the size of Guyana, given the size of the power system, we don't want to experiment with new things like a 10 MW solar thermal power generation system. One would like some assurance that whatever investments are made, will work. I am only saying that the paper I am referring to provides that kind of re-assurance because these were the very issues that were relevant at that point in time and, if anything, today they acquire much greater relevance.

This is the forecast summary for power requirement and, as you notice, the future interconnected system based on the forecast was for 354 MW. I suppose that is of historical importance now. But it just shows a very optimistic picture which has not materialized.

The demand for energy and power is undoubtedly going to be determined by a range of variables, , the most important of which would be the level of activity in each sector of the economy that consumes energy Prices would be critically important because the inter-fuel mix and the technology that's adopted for the use of energy is critically dependent on the prices of energy that exist in the market. If one is moving the system toward some kind of desired supply-mix then one needs to very consciously look at the market signals which the supply may send and the kind of policy package that would bring about that supply shift in the future

All of them are not entirely relevant here but we can consider some examples The French, after the first and second oil price shock, decided as a matter of conscious policy to reduce their dependence on oil imports and they picked on nuclear power development as the preferred mode As a result, they have perfected and standardized designs of nuclear power plants. They have also standardized their project management to expand capacity substantially, now 80% of the power in France comes from nuclear sources.

I am not for one moment endorsing that policy, I am only putting it forward as an example of how the mix in energy supply can be brought about as part of a conscious strategy.

The other example is that of Japan, another country which wanted to reduce its dependence on oil imports and therefore went in for large-scale imports of natural gas as a form of energy It also did away with energy-intensive industries and decided, for instance, to import aluminium rather than produce it in the country. The result was that most of the energy-intensive industries were more or less shut down and the Japanese concentrated on the so called 'sunshine' industries. So, there was an effort on the demand side and the supply side to alter the future mix of energy sources, and this is precisely what I think your energy policy of Guyana is attempting to do. What we need now is the right set of market signals, the right contractual framework So one must make a conscious attempt to see that the right framework is put in place, whereby a move takes place from the current energy situation to a more robust energy future for the country

Current energy situation: demand and supply issues, status of the power sector—part II

Guyana Electricity Corporation

Introduction

The Guyana Electricity Corporation (GEC) is a state-owned electric power utility with the responsibility for the generation, transmission, and distribution of electricity in the populated areas of the coastland including the islands of Wakenaam and Leguan.

The GEC owns a total of nine power stations, of which seven utilize No. 2 light fuel oil in internal combustion diesel prime movers. One of the other two stations utilizes No 6 heavy fuel oil in internal combustion diesel prime movers, and the other utilizes residual Bunker 'C' heavy fuel oil in a boiler/turbine steam power station In addition, the corporation has two gas turbines which were donated by the Brazilian government to the Government of Guyana (GOG) and a Power Barge which was acquired in 1989 as a used facility.

The generating stations in the Berbice and Demerara systems, including the LINEMINE power station, are interconnected by a 69 kV grid, with the exception of the portion of the system from the Sophia converter station to the Onverwagt power station which can only be linked via adjacent 13 kV feeders

The other generating stations in the system are all isolated and are located along the coastland. They have diesel generating units ranging in capacity from 0.4 MW to 2 0 MW.

The organization

The operations of the GEC are effected by a 1025 strong work force comprising of 109 management staff and 916 non-management staff. The management staff includes corporate, senior, and middle management personnel A Board of Directors is responsible for the policy issues related to the functioning of the organization and the subject minister for the corporation is the Prime Minister

Legal and regulatory framework

The GEC is required to conform to and is regulated by the following laws and national policy:

Laws of Guyana
The Electricity Act, Chapter 56:01, and Amendments thereto
The Electric Lighting Act, Chapter 56:02, and Amendments thereto and
The Public Utilities Commission Act No. 26 of 1990 and Amendments thereto

Other general laws which are applicable to the Corporation

The Income Tax Act, Chapter 81:01
The Labour Act, Chapter 98:01
The Factories Act, Chapter 95:02

The National Energy Policy

Though not a legal document as yet, it sets out the guidelines and desired direction of thrust for the energy sector.

Generating facilities

A list of the GEC's installed generating capacity is shown in Table 1

Kingston power station

The Kingston power station, which is more than 30 years old, has three 10 MW steam turbines installed The current nominal availability power from this station is 25 MW

In addition, the two 20 MW gas turbines donated by the Brazilian government are also installed at this location. Neither of the latter two units is currently operational

Demerara Power Company (Wartsila Units)

This station has two 5.5 MW diesel generating units operating on No 6 heavy fuel oil with a total installed capacity of 11 MW. The station was commissioned in March 1994 and is capable of producing its maximum capacity

Garden-of-Eden power station

The Garden-of-Eden power station has four 5.7 MW diesel units. The nominal availability of power from two of these units are 4 MW from the No. 5 and 2 MW from the No 4 unit. Of the two remaining units, the No. 3 is not expected to be rehabilitated The other unit, the No. 2, was recently rehabilitated by the original manufacturer and power is available at 5 0 MW.

Canefield power station

The Canefield power station has two 5.7 MW diesel generating units installed. Both units were commissioned in 1979. Rehabilitation of both units was recently completed as part of the IDB rehabilitation programme and has an availability of 2.0 MW of power

Versailles power station

The Versailles power station has three 1.6 MW diesel generating units installed, which were commissioned in 1985 These units were last rehabilitated in December 1994 by a team of Japanese engineers under the Japanese Grant Aid Programme. The available generating capacity of this station is 4 2 MW which is adequate to meet the maximum demand in West Demerara. These units are capable, by design, of a 2 0 MW rated output when operated at 60 Hz.

Table 1. *Guyana Electricity Corporation* Installed capacity of existing power plants (as on January 1996)

Power plant	Kind of engine	Manufacturer	Model	Installed capacity (MW)	Unit no × capacity (MW)	Available capacity (MW)	Commissioning Year	Frequency 50 or 60 Hz
Kingston B		Boiler International Combustion Ltd UK	Foster Wheeler	30		25 5		50 Hz
No 1	Steam/Bunker 'C'	Turbine (H6-47) Associated	R 4606		10	8 5	1963	
No 2	Steam/Bunker 'C'	Electrical Industries Ltd, UK	R 4607		10	8 5	1964	
No 3	Steam/Bunker 'C'	Alternator AEI			10	8 5	1967	
Gas turbine		General Electric		20		0		60 Hz
No 1	Diesel				10	0	1991	
No 2	Diesel				10	0	1993	
Garden-of-Eden				22 8		11 5		60 Hz
No 2	Diesel	Engine Crossley Pielstick UK Alternator GEC, UK	PC2 3V16		5 7	5	1976	
No 3	Diesel	ditto	PC2 3V16		5 7	0	1976	
No 4	Diesel	ditto	PC2 3V16		5 7	2 5	1976	
No 5	Diesel	Engine Niigata Pielstick Japan Alternator Nishishiba Electric Co	18V32		5 7	4	1991	
Versailles		Engine Niigata Engineering Co. Ltd, Japan Alternator Nishishiba Electric Co		4 8		4 2		50Hz/60Hz
No 1 2 0 or	Diesel		12VPAS		1 6	1 4	1985	
No 2 2 0 or	Diesel		12VPAS		1 6	1 4	1985	
No 3 2 0 or	Diesel		12VPAS		1.6	1 4	1985	
Onverwagt		Engine General Motors, USA		2 5		2 4		60 Hz
No. 5	Diesel	Alternator General Motors	EMD564B		2 5	2 4	1981	
Canefield		Engine Mirrlees Blackstone UK		11 6		10		60 Hz
No 3	Diesel/HFO		KVMAJOR16		5 8	5	1979	
No 4	Diesel/HFO		KVMAJOR 16		5 8	5	1979	

Contd

contd

Power plant	Kind of engine	Manufacturer	Model	Installed capacity (MW)	Unit no x capacity (MW)	Available capacity (MW)	Commis-sioning Year	Frequency 50 or 60 Hz
Anna Regina	·	Engine Ruston, UK Alternator AEI, UK		2		0		50Hz
No 1	Diesel		8RK3C		0	0	1972	
No 2	Diesel		8RK3C		0	0	1972	
No 3	Diesel		8RK3C		0	0	1975	
No 4	Diesel		16RK3C		2	0	1986	
Anna Regina, Wartsila		Engine Wartsila VASA 32 Finland Alternator ABB		4		4		50Hz
No 1	Diesel/HFO		6R32		2	2	1995	
No 2	Diesel/HFO		6R32		2	2	1995	
Bartica		Engine Mirrlees Blackstone, UK Alternator Brush Electric, U K		0 8		0 8		60Hz
No 1	Diesel		ESS6		0 4	0 4	1974	
No 2	Diesel		ESS6		0 4	0 4	1974	
Wakenaam		Engine General Motors, USA		0 5		0 5		60Hz
No 3	Diesel	Alternator General Motors	EMD 567C		0 5	0 5	1980	
Demerara Power Company, Garden-of-Eden		Engine Wartsila, Finland Alternator ABB	18V32 HSG900	11 0		11 0		60Hz
No 1	Diesel/HFO				5 5	5 5	1994	
No 2	Diesel/HFO				5 5	5.5	1994	
Sophia		Engine Caterpillar, USA Alternator Caterpillar		6		5 6		
No 1	Diesel		Cat 3516		1 5	1 4	1995	60Hz
No 2	Diesel		Cat 3516		1 5	1 4	1995	60Hz
No 3	Diesel		Cat 3516		1 5	1 4	1995	60Hz
No 4	Diesel		Cat 3516		1 5	1 4	1995	60Hz
Total				116	116	75 5		

Anna Regina power station

The Anna Regina power station has two, 2 MW diesel units which were commissioned in May 1995. This capacity is more than sufficient to meet the present maximum demand of this isolated system

Wakenaam power station

The Wakenaam power station has a single 0.5 MW diesel generator installed and has sufficient capacity to meet the peak demand on this island.

Bartica power station

The Bartica power station has two 0.4 MW diesel generating units installed each having sufficient capacity to meet the peak demand in this isolated system.

Transmission and distribution facilities

The GEC transmission system comprises of 69 kV transmission lines from Linden to Garden-of-Eden, Garden-of-Eden to Sophia, Onverwagt to Canefield, and Canefield to No. 53 village.

The distribution system within the interconnected system has primary voltages of 4 kV and 11 kV at 50 Hz while the primary voltages for the 60 Hz system are 2.3 kV and 13.8 kV.

Table 2 shows a listing of the transmission facilities and substations.

The above mentioned nine generating facilities provide the major part of the energy requirements of the system with purchases from LINMINE supplementing the energy generated.

The performance of the GEC, over a number of years, has suffered from the lack of sufficient firm generating capacity and the lack of sufficient funds to carry out the maintenance required.

Table 2 Transmission line plant (as of March 1996)

Section	Voltage (kV)	Length (Km)	No of circuits	Commissioning year	Remarks
(Existing)					
Linden to Garden-of-Eden	69	82	1	1976	All circuits are of conductor type
Garden-of-Eden to Sophia	69	29	1	1977	ACSR and size 266.8 MCM
Onverwagt to Canefield	69	42	1	1978	
Canefield to No 53 Sub-station	69	56	1	1987	
(Planned-short term)					
Sophia to Onverwagt	69	74	1	ua	ua

Note 'ua' means unavailable

Production

The GEC in the past has had tremendous difficulties in ensuring that its production matched the demand. This situation though has been steadily improving over the recent past, and in particular over the past two years.

The total energy generated by the GEC power stations for 1989 was 159 GWh as compared to 334 GWh in 1995. The projected generation for 1996 is 348 GWh and the actual to March 1996 was 82 GWh. This represents a 110% increase in six years. The production for the years 1989–1995 is included in Table 3.

This increase has not been due to load growth only, but represents a significant decrease in the energy not served. The estimated energy not served in 1989 was 91 GWh, compared to the approximate figure of 15 GWh for 1995, a decline of 84%.

In 1989, the government acquired a used power barge, the operation of which proved quite unsuccessful and the barge has since been retired. Neither the gas turbines nor the barge came close to fulfilling their expectations.

At present, the production of electricity by the GEC reasonably matches the demand Figure 1a, 1b, and 1c show typical 24 hour load curves for a weekday and a weekend for the linked Demerara and Berbice systems with all distribution circuits in service However, interruptions of power supply to consumers still exist and are caused by a number of factors, among which are the following:

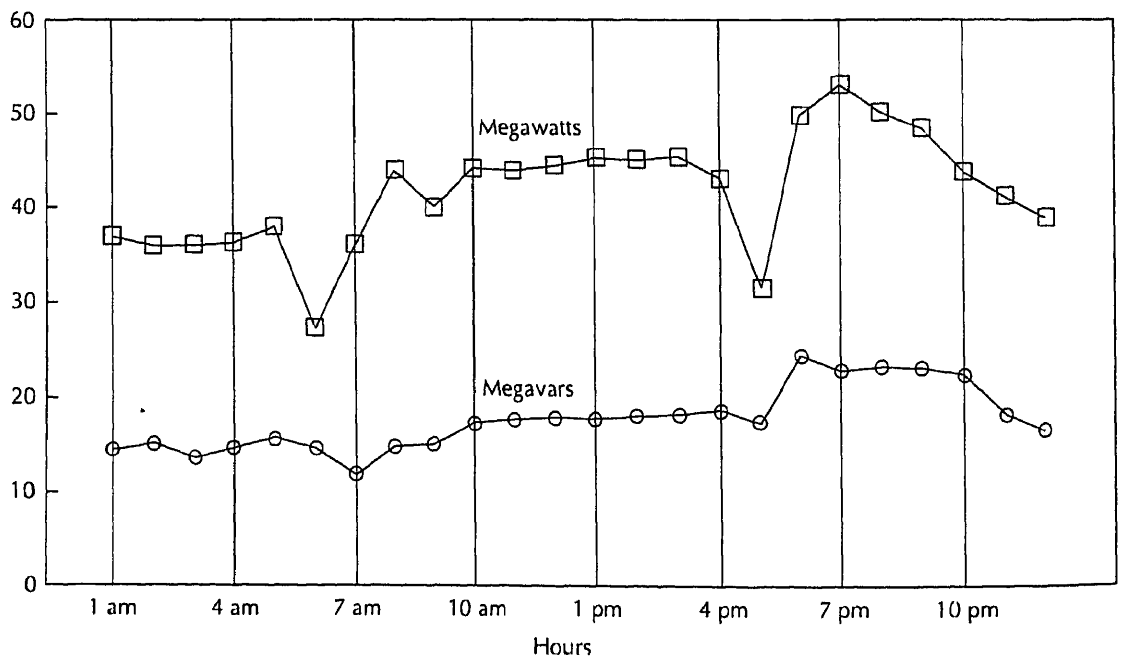


Figure 1a Typical weekday load curve

Table 3 Total GEC system—(regions 2, 3, 4, 5, 6, 7) energy generated, sold, losses, and peak demand

Particulars	Unit	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
No of consumers	No	85606	101359	91026	89567	99337	ua	95046	96294	98828	ua
Energy sold	MWh	161500	178900	161600	121600	150500	161100	163800	226334	229386	ua
Losses	MWh	69182	47756	72356	62652	54262	61415	80367	28977	52975	ua
	%	30 0%	21 1%	30 9%	34 0%	26 5%	27 6%	32 9%	11 3%	18 8%	ua
Net generation	MWh	230682	226656	233956	184252	204762	222515	244167	255311	282361	317653
Auxiliary Station Use	MWh	12212	11412	11357	7971	7678	9430	10737	10135	13449	16117
	%	5 4%	5 3%	5 2%	5 0%	4 0%	4 3%	4 5%	3 8%	4 5%	4 8%
Generating Stations	MWh	12212	11412	11357	7971	7678	9430	10737	10135	13449	16117
Sophia converter/ Control centre	MWh	ua	ua	ua	ua	ua	ua	ua	ua	ua	ua
Total generation	MWh	242894	238068	245313	192223	212440	231945	254904	265446	295810	333770
GEC gross generation		226146	215324	218413	159 423	191940	219293	238602	253160	290835	333681
Purchases		16748	22744	26900	32800	20500	12652	16302	12286	4975	89
Peak demand (Non-coincident)	MW	47 0	45 7	46 4	39 8	41 8	44 1	48 2	56 1	56 8	62 6
Reserve	MW	ua	ua	ua	ua	ua	ua	6 7	0 8	9 1	12 9
Nominal guaranteed Capacity	MW	ua	ua	ua	ua	ua	ua	54 9	53 9	65 9	75 5
Installed capacity	MW	ua	ua	ua	ua	ua	ua	85 0	97 0	106 0	116 0
Load factor	%	59%	59%	60%	55%	58%	60%	60%	54%	59%	61%
Energy not served	MWh	ua	ua	ua	ua	ua	ua	ua	ua	ua	ua
Demand suppressed	Y/N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total metered feeder energy	MWh	ua	ua	ua	ua	ua	ua	ua	ua	ua	ua

Note: 'ua'—Information unavailable at time of data compilation

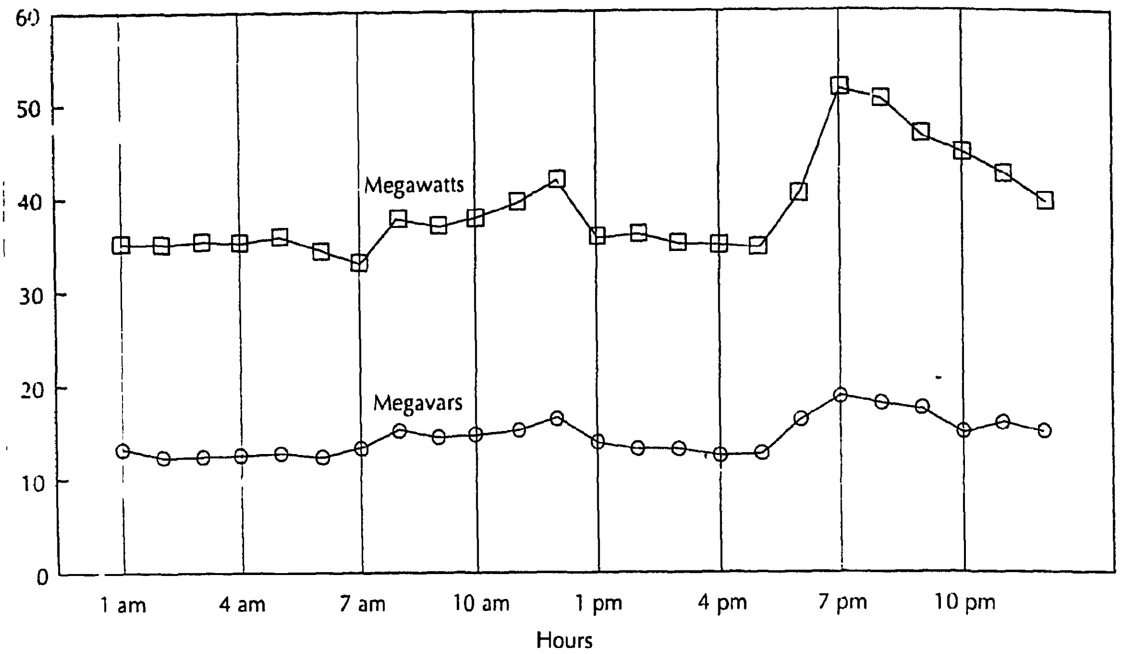


Figure 1b. Typical Saturday load curve

- The lack of reserves in the power stations supplying electricity to the main load center. (This leads to a generation shortfall when major generating equipments are shut down for planned or emergency maintenance), and
- Isolation of transmission and distribution system components so as to carry out planned or emergency maintenance

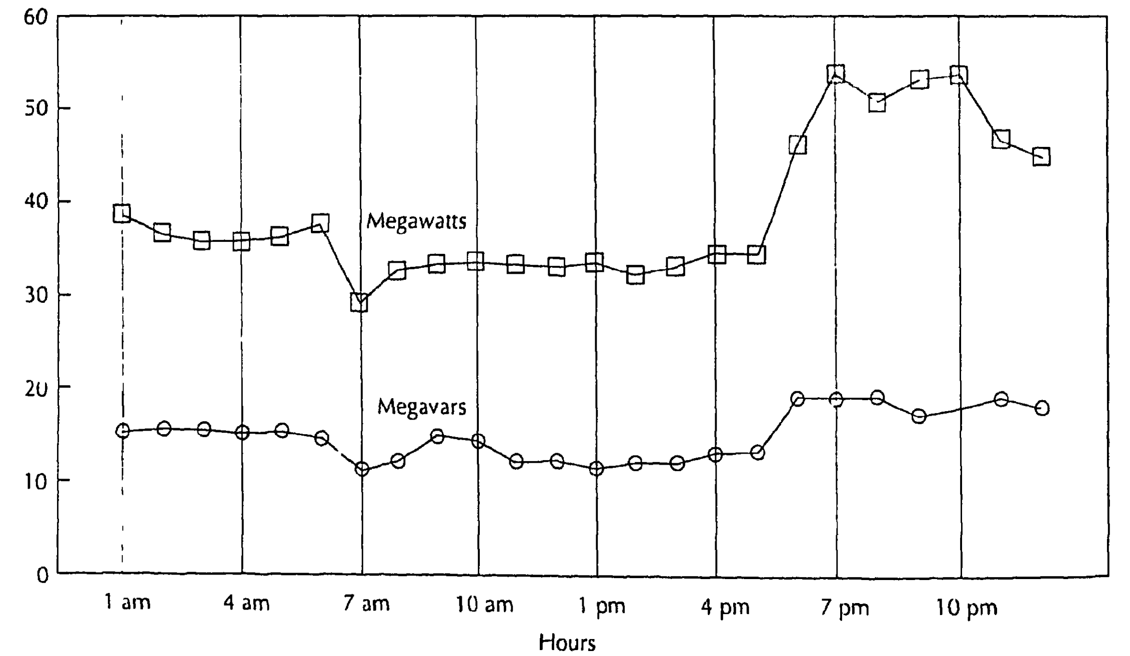


Figure 1c Typical Sunday load curve

Table 4a Average unit costs for generation by station

Station	Generation (G $/kWh)
Kingston 'B'	9 15
Versailles	8 36
Garden-of-Eden	9 72
Canefield	8 34
Anna Regina	11 21
Wakenaam	17 17
Bartica	12 21
Damerara Power Company	7.81
Onverwagt	10.80

Table 4b Average unit costs for combined T & D by operational geographic areas

Operational geographic areas	Transmission and distribution (G $/MWh)
Central Demerara	
South Demerara	
East Demerara	
West Demerara	
West Berbice	
East Berbice	
Essequibo & Islands (Coast, Bartica and Wakenaam)	
Total T & D system	6 15

Generation and distribution costs

The performance of GEC was compounded by the fact that the rates charged for the use of electricity were below the cost of service, resulting in the GEC receiving large subsidies from the government to cover operational expenses. This effectively precluded the GEC from investing in new plants Table 4a and 4b give average unit costs for generation by station and that for combined transmission and distribution.

Commercial/financial performance

Not being in a position to finance new plants, the GEC relied on the support of the Inter-American Development Bank (IDB) to rehabilitate some of the generating plants as well as the distribution network.

Subsidies

During the period mentioned above, the government provided substantial subsidies to the GEC to cover operational expenses. The total for the period 1989–1993 was $3.2 billion. No subsidies were provided for 1994 or 1995 and the GEC is not expected to receive any further subsidies from the government to cover operational expenses.

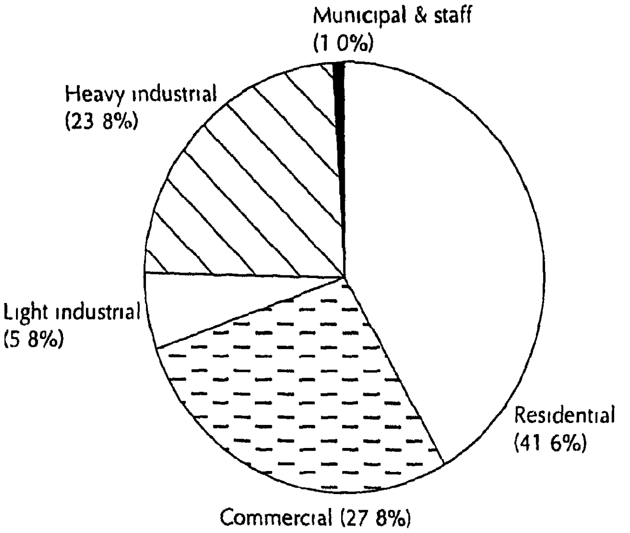


Figure 2 Revenue distribution by tariff

It is important to note that the average tariff for the period 1981–1986 was US cents 20 as compared to the current average tariff of US cents 12 Figure 2 gives pie chart view of these distributions.

IDB rehabilitation programme

The IDB Rehabilitation Programme, which commenced in 1985, is aimed at rehabilitating GEC's main generating facilities, as well as part of the distribution network

Financing for the Programme under the Original Loan Lo-163/IC-GY was insufficient to complete the Programme due mainly to increased costs for off-shore materials This was brought about by delays incurred because of the performance of the original consultants of the Project Executing Unit, Gibbs and Hill, and to the appreciation of the Pound Sterling against the US Dollar.

As a result, it was necessary for the GOG to negotiate with the IDB, Supplementary Loan 8852/SF-GY in the sum of US $15.5 million to finance the remainder of the programme This supplementary loan was negotiated in 1991.

Plans and programmes

General

As part of its strategic planning, the GEC is required to constantly review its plans and projections for future load growth and generation requirements

There were a number of studies carried out in the past which produced load forecasts, the latest of which was done by the Canadian International Power (CIP) as part of an Integrated Investment Plan (IIP). This plan, however, concentrated only on the Inter-connected System.

The IIP, while being fairly comprehensive, had to be reviewed primarily due to the premature failure of some of the generating plants, in particular at the Garden-of-Eden power station.

Due to the fact that the generating units at Garden-of-Eden power station failed prematurely, it was necessary to install additional generation (an 11 MW plant) in the Inter-connected System ahead of schedule.

This factor contributed significantly to altering the plans proposed in the IIP. In addition, a recent study funded by the IDB indicated that a significant load, mainly industrial, was still not being served by the GEC. As a consequence, the load forecast was revised, taking into consideration these factors.

It is pertinent to mention that a long-term indicative expansion plan is to be prepared by a consultant under the current IDB programme. This plan is expected to be submitted by the first quarter of 1996.

Load forecast

The latest load forecast which was done for the GEC's Inter-connected System was done by the CIP in 1991. This forecast took into consideration forecasts done previously by consulting Firms JICA and MONENCO. In the forecast three scenarios were considered, high, low and medium. Of the three, the medium forecast was considered as the most realistic. This scenario is therefore considered as the base forecast for this review.

Despite the fact that decisions now required are for the next two to five years, the forecast was revised for a period of fifteen years in order to give a long-term perspective and to analyse the impact of solutions proposed on possible long-term solutions.

The CIP medium forecast was used as the basis for arriving at a revised forecast. This forecast generally assumed a significant growth rate in the order of eight to nine percent in the country's economy for the period 1995–1997. Much lower growths are assumed for the later years.

The revised forecast maintains these assumptions with the following additional assumptions:

(a) In the starting year for the forecast 1995, it was projected that the load would be 55 MW. This is based on the fact that the actual maximum demand then on the Inter-connected system was of that order.
(b) There is a significant load (mainly industrial) not connected to the GEC's system. This load has been determined to be of the order of 15 MW. Most of these industries have shown a reluctance to use GEC's power as the main source of supply for a number of reasons, including reliability and their current cost of generation which in most cases does not include capital investment.

It is assumed that these industries will be unwilling to use the GEC's supply until the reliability of the supply can be established. In any event, a number of these industries may not be willing to do so immediately after the GEC has demonstrated that they can provide a reliable supply, since they have either already invested in new base load plant or are in the final stages of doing so.

Table 5 Load and energy forecast (1995-2009)

Year	Peak Load (MW)		Energy (GWh)	
	CIP	Revised	CIP	Revised
1996	62.00	60 35	326	352
1997	67.50	70 71	355	372
1998	69 60	77 91	366	409
1999	71 60	85 15	376	448
2000	73.70	87 64	387	461
2001	76 50	90 97	402	478
2002	79 50	94 54	418	497
2003	82.50	98 11	434	516
2004	85 60	101 80	450	535
2005	88 90	105 72	467	556
2006	92 40	109 88	486	578
2007	96.00	114 16	505	600
2008	99 70	118 56	524	623
2009	103 50	123 08	544	647

As a result, the revised forecast assumed that these industries will only return to the GEC's system starting in 1997. An additional 5 MW of load is therefore projected for the years 1997, 1998, and 1999. This is above the normal projected load growth

This revised forecast is considered to be a high forecast, since a number of the industries that are expected to return to the GEC's system have insisted that they will continue to operate their own generating facilities, even if the GEC's supply stabilizes Both the CIP's load forecast and the revised load forecast are included in Table 5.

Energy forecast

The CIP's energy forecast generally assumed a system load factor of sixty per cent (60%). This figure when compared to the present system load factor is considered low For the first two years of the forecast, a load factor of the order of 67%, which is in keeping with the current load factor, was used. For the remaining years, a load factor of 60% was used. This reduction in load factor is anticipated due to the connection of the unserved industrial load to the GEC's system. Both the CIP's energy forecast and the revised energy forecast are included in Table 5.

Generation forecast

The generation forecast takes into consideration the retirement schedule of the existing plants within the system and an additional 5 MW of Japanese Grant Aid.

Retirement schedule 1995

For the Kingston power plant it is assumed that one unit will be retired each year starting 1998. The retirement schedule for this station is a major factor in the plans for the GEC It should be noted that previous forecasts indicated that the station would have to be retired earlier than indicated in this report. This revised retirement schedule has been influenced mainly by the fact

that the rehabilitation works that were delayed under the IDB programme will now be completed in 1996. This retirement schedule for the station is considered to be realistic.

The gas turbines were initially expected to be decommissioned by the end of 1996. However, recent failures experienced have dictated that they be retired at the present time.

The retirement schedule for the Garden-of-Eden assumes that the refurbished units will be in service for five years after rehabilitation.

The retirement schedule of the other plants is generally in keeping with the schedule proposed in previous studies. The Wartsila plant operated by the Demerara Power Company which was not included in previous studies, will not be retired during the period under review.

In the case of the Barge, plans are in the pipeline for its disposal while a decision on the Gas Turbine is awaiting a report from the Cuban firm, Cuvastec, which was contracted to commission the No 1 Gas Turbine.

Scheduled activities

Station	Unit	Remarks
Kingston	No 3 Boiler	Tube replacement for this unit is scheduled for the first half of 1996 under the IDB Rehabilitation Programme
	No 1 Turbine & Alternator	The rotor for this turbine is scheduled to be replaced in the first half of 1996 and the alternator rotor refurbished during the same period
	No 2 Turbine	External inspection planned to coincide with the statutory maintenance of the No 2 boiler Internal inspection planned for 1996
	No 3 Turbine	External inspection planned to coincide with the statutory maintenance of No 3 boiler Internal inspection planned for 1996
Onvergagt	No 5 D/A	Based on the operating regime of peaking, system support during emergencies and generation shortfall due to planned maintenance, the next major overhaul of this unit is scheduled for the third quarter of 1996
Versailles	No 1 D/A	A major overhaul of this set was completed 2 December 1994 with supervision from a team of Japanese service engineers The next major overhaul is due in the first quarter of 1997
	No 2 D/A	A major overhaul of this set was completed on 3 November 1994 with supervision from a team of Japanese service engineers The next major overhaul of this set is due in the last quarter of 1996
	No. 3 D/A	Major overhaul completed on 18 November 1994 with Japanese supervision Next major overhaul is due in the last quarter of 1996
Bartica	No. 1 D/A	Major overhaul completed in March 1995 Next Major overhaul due in second quarter of 1997
	No 2 D/A	No major overhaul was planned for 1995. However, the next major overhaul is scheduled for the last quarter of 1996
Wakenaam	No 1 D/A	This unit is scheduled to be replaced during the first quarter of 1996

Additional generation

To alleviate the existing power supply interruptions, the corporation has progressed with plans for the installation of an additional 11 MW plant expansion at Garden-of-Eden which is expected to be commissioned by the second half of 1996. Additionally, the 5 MW set to be provided by the Japanese government as part of that country's Grant Aid Programme is scheduled to be commissioned during 1997.

Towards the end of 1995, the GOG, after long discussions with the IDB, agreed on a programme to invite, appraise, and select a foreign electric utility or utility-led consortium to invest in and participate in the formation of a new larger GEC. It is expected that the core partner for the new GEC would be selected before the end of 1996.

Status of the sugar industry and future trends and the availability of biomass fuel for cogeneration

Guyana Sugar Company

The present position of Guyana Sugar Company (GUYSUCO), where it is at the moment, and the problems it is facing, the future plans and the constraints imposed on the industry in trying to achieve those plans and the relevance of cogeneration to GUYSUCO are discussed here.

Sugarcane has been grown in Guyana for 362 years. It really came of age in the eighteenth century It is now being cultivated on over 42 000 hectares of land. The industry involves 28 000 people directly and probably another 8000 people indirectly. It is responsible for 28% of gross domestic product (GDP) of this country, all the foreign earnings, a major section of the country as a whole and with that come about 68% of all the agricultural production here in Guyana.

GUYSUCO posseses eight operating units, four in Demerara, four in Berbice, one of the Berbice factories is on this side of the Berbice River. It almost falls in what would be classed as Demerara region, but two of the Demerara factories are to the north, on the other side of the bridge.

In 1990, the industry produced a low of 130 000 tonnes of sugar. It was a terrible state following an era of low investments, severe industrial unrest, etc. That has been turned around and now somewhere in the region of 260 000 tonnes/year of sugar has been produced over the last four years and this has been achieved through a particular period when there has been actually little industrial unrest There has been a distinct change in management commitment, change in working practices, and an admirable response to the challenges that have been offered to the lower management But perhaps one of the more fundamental things is actually being supplied with spares, fertilizer consumables, and a goal for the future

In addition, it provides the Government of Guyana a sugar levy of something like G $2 billion a year That goes into the government for provision of basic development of Guyana.

There are eight factories. The problem at the moment is most of the equipment is worn out. A list of some of the equipment here is: the main milling tandems, Skeldon 1970, Rose Hall 1953; Blairmont, 1919; Wales, 1919; Uitvlugt, 1919; all due for immediate replacement. The boiler plants, are anything from 1930s right through to some of the most recent items in 1971. Some of the sugar plants and the process house, are 102 years old. So, there is a very weak assets base in the company; something that needs addressing at an early age, at an earlier moment in time. It would require somewhere in the region of US $100–120 million spent over the next five years to guarantee security of supply of sugar.

Thirty-two to thirty-four weeks a year, split into two crops; that is 2/3 of the year is the operating period. The facilities to supply that baseload has to be supplied from somewhere else. May be one of the boilers can be developed but it can't come from bagasse.

One of the more worrying issues is, the operating period. The Demerara region operates say 107 hours a week out of 168. The Berbice, 125 hours. The industry improving products from 30 000 tonnes to the 260 000 tonnes. That has come through improving factory efficiency. Those efficiencies now are up to international sugar standards—90–94% at some factories. A big gap is left by 94% of 168.

There are three basic reasons why this is so. The weather accounts for about a third of it, delivery of cane to the factory, another third, and industrial unrest, another third. The out of-date figures include the amount of studies that don't go down on paper. So, industrial unrest is a major factor in GUYSUCO as it stands and operates in its present format

They have improved from about 70% to over 80% efficiency towards international standards.

With reference to cogeneration, the amount of supplementary fuels that are needed are remarkably reduced. By improving factory time and operating efficiencies, the use of diesel as a supplementary fuel has been cut down by about 30–40% over the last few years. Use of wood as a supplementary fuel in the factories has also been cut down. Despite these gains in production, the cost per tonne on US $ is increasing at about 10% per annum—a no-win situation. So despite all these improvements, in terms of viability of a long-term industry there is no gain.

The industry, in its present environment receives subsidized process for its sugar. It sells sugar into the EC, US, CARICON and these markets have subsidized process or support prices, as people prefer to call them. That, under the Free Trade agreements, the breaking up of GAP, the pressures under the LOME Convention, the changes in Europe, and even the failure of Germany to qualify as a country capable of joining monetary union in Europe at the moment and France as well Those countries are going to put increasing pressure on reducing subsidies to the outside world. The governments would be forced to look after themselves. So what is predicted is decreasing revenue from sugar to Guyana.

In the future 300 000 tonnes from eight operating units are being looked at The Prime Minister talked about possible factors for rationalization, something that has to be considered seriously if the cost from production has to be brought down. Within that plan, Skeldon factory has to go up from 90 tonnes of cane an hour to 120 tonnes of cane an hour, Albion from 165 to 170, Rose Hall, 115 to 130 tonnes of cane an hour and Blairmont from 100 to 110 an hour

In the Demerara Region, there is a hope for the present production level as things stand. So far, factories capable of cogeneration of 10–11 MW, 6000 tonnes a day, 5000 tonnes a day, 250 tonnes an hour—double the size of the standard Guyanese factory—have been looked at. That is a major problem in cogeneration, because one has a phased load in a factory, and a small asset base to generate to the capacity of a much larger unit and that is where technical problems start

GUYSUCO has poor asset conditions, which need US $100 million spent urgently. The only thing that can be guaranteed about the Guyanese industry is that there will be loss of factory at

some time in the next five years or a crop if this amount is not spent. It could be for two crops, if things went badly wrong .

The constraint that the government is posing on the industry is that the finance has to be from self-generated funds, which can go up to G $3 billion a year. Tax has to be paid on the capital goods coming in to rehabilitate that industry So 20% of the $100 million goes on tax and import duties. There are factories which are draining the wealth of the company. They are loss-making institutions, from an accounting point of view. It has considerable problems of its own in the near future

The first priority for GUYSUCO is to protect its asset base, that comes in the form of the capital money and skills. It has a major problem with loss of skills. It is loosing two to three senior managers a year to America. There cannot be replaced overnight. It would take five to seven years to get well-trained people to speed up, provided they have the right training in that area.

The overall factory performance and the extraction improvements that have been gained to date must not be sacrificed. There is a fundamental interlinking between what can be taken out from a piece of sugarcane, from the manner of water added to it, and the manner of preparation that is done to that cane before adding the water. To optimize cogeneration at a sugar factory, those two parameters have to be compromised because steam is needed to evaporate the water. Movement from four effect evaporation to five effect evaporation needs better control in the factory It needs less stale, it means operating the equipment at tighter tolerances. At the moment, that is outside the capabilities of staff that is there and the pressures on the industry. It has to address the issue of cost. It cannot carry on with US $5 a tonne increase in cost It cannot do it because there is a fall in market price in five to six years time. This year, 25% pay rise and say 20% of pay rise coming through the next year are planned. It cannot carry on that way and to go through these is always painful, but it has happened all through Europe, America, and South Africa Change involves industrial unrest.

Furthermore, around the world the sugar industry must control itself. It cannot be at the mercy of an outside agency. For Guyana, this is such an important business. It has to run itself as a co-business as profitably as it can

Energy costs have been dropped by 50% in British sugar over four years when the oil price hike came in the late 1970s. Private degradable fuels burning straw were considered. But the fact was that the oil price came down and it was not viable as a private business to burn a renewable energy resource So while the energy oil prices stayed down, the private businesses were forced to continue burning the fossilized fuels. But that does not mean that the oil prices will stay where they are They are fluctuating but in real terms one is still talking about the same price that it was in 1993 ($16) and 1994 ($17) a barrel.

The sugar industry is built around cogeneration. It was the leader in cogeneration during the late 1800s and the early 1900s All the energy technologists in the world, before oil came on the market, came from sugar. Fibre in cane will give one per cent less or more sugar to the bag because of the loss at the grinding stage and milling stage.

If cane growing for cogeneration has to be optimized and 80% fibres are needed, then the cost has to be considered. Some of the studies that have been done on Guyana are presented here.

They are 100 MW being generated from processing units generating 20 MW. The 20 MW study has been based on a factory at Albion which processes 170 tonnes cane an hour at the moment. The study was done on the basis that the Rose Hall factory was closed and cane would be transferred to Albion factory and the capacity of Albion factory would be wound up to 250–260 tonnes an hour. That study also assumed 94% operating efficiencies and time efficiencies. In reality there are about 125–127 on that estate. That study also assumed the expansion of the factory. Money would be spent by GUYSUCO to tailor the factory to handle energy efficiently. Those costs did not go to the cogeneration, it was assumed that they would be done.

For cogeneration to work, big factories are needed. There are factories with 5000–6000 tonnes a day. These have to be put up in areas where lignite is available, so they can run the factory in that period of the year when they are not operating on lignite. Boilers have to be run at 400 °C plus. But the turbines are all geared for 350 °C. That's the maximum operating temperatures of the turbines Then cast steel and more high-tech materials have to be considered for the system, something the industry would not do all of its own accord So large factories, high fibre in cane to give excess power, 365 day operation, and high calibre staff for operating calcite turbines with computer controls, etc., are needed

There is a difficulty in recruiting instrument engineers to manage basic instrumentation in the factories. Efficient factories are needed but the government insists investments in rehabilitation programmes with self-generated funds. The rehabilitation will not be quick enough to hold on to the production levels at 300 000 tonnes in the time that is available.

Sustainable industry has to survive if it is going to be of assistance in cogeneration. If we hang on a condensing set at the back of the factory, we can produce 1 MW, 24 hours a day, 7 days a week; 2 MW at some factories, up to 3 MW when Rose Hall is expand at the high levels of fibres that they are experiencing the moment, 172 MW at the fibre levels targeted in the next two years

Status of rice industry and future trends and the availability of biomass fuel for cogeneration

Kayman Sankar & Company Limited, Guyan Natural Resources Agency

Introduction

The use of biomass to produce electricity by means of steam technology is not new to Guyana. At present, in the sugar industry and some large sawmills, waste residues from these operations are utilized as fuel for their steam generators In the rice industry, some of the rice mills with parboiling systems utilize rice husk as the primary fuel for boilers in order to have steam for its operations

In 1988, Kayman Sankar and Company Ltd, purchased a thermo-electrical plant from a Brazilian company—Mernak and installed it at Hampton Court on the Essequibo coast. This plant uses rice husk as its fuel and was the first of its kind to be installed in Guyana Previously, diesel generators were used to supply the power needs for the operations of the complex since at that time, the Guyana Electricity Corporation (GEC) was unable to satisfy the needs on the Essequibo Coast. The thermo-electrical plant consists of two fire-tube boilers and four steam engines/generators and has a total rated capacity of 720 kVA.

For the drying, storage, and milling operations the thermo-electrical plant provides all the power requirements of the complex In the out-of-crop season, the plant is down for maintenance and power is supplied by the Guyana Electricity Corporation because it is more economical this way than to generate power with the diesel generator The diesel generators are there as standby facilities

Technical specifications

Technical specifications of the main equipment of the thermo-electrical plant at Hampton Court, Essequibo Coast

• Boiler	
Heating surface	200 m^2
Steam production	4000–4400 kg/hr
Steam exit diameter	100 mm
Water capacity	8.5 m^3
Steam capacity	1.64 m^3
Diameter of steam boiler	2.21 m
• Steam Engines	
Power	200 HP
Steam consumption	2000–2300 kg/hr
Working pressure	14 kg/cm^2

- Synchronous alternator–generator

Power	180 kVA (144 kW)
Volts	440
Amperes	236
Power factor	0.8
Excitation	20 volts, 55 amperes
Frequency	50 Hz; three-phase
Speed	1500 rpm

Rice husk production

Rice husk is approximately 20% of paddy by weight At Hampton Court, the mill processes 125 bags (145 lbs/bag) of paddy/hour; this is equivalent to 8.0 tonnes/hour So, the rice husk production is estimated at 1.60 tonnes/hour.

Description of the systems at the thermo-electrical plant

The operations of the thermo-electrical plant is divided into several sections, namely:

- Husk feeding system
- Furnace and boiler
- Water supply system
- Air control system
- Ash disposal system
- Steam engines
- Generators
- Electrical control system

Husk feeding system

Husk is transported and fed into the furnace by means of belt conveyors, bucket elevators, and screw conveyors. The system is designed to discharge 1.5 tonnes of husk per hour. There must be adequate husk in store or available to feed the furnace to maintain the required operable steam pressure.

Furnace and boiler

For firing-up of the furnace, adequate husk is fed into the furnaces and then set alight. The fire is kept low initially and gradually rises as the furnaces are heated up properly. Care is taken not to overfeed the furnace since it would affect air circulation and combustion. The husk is burnt on a slant and fixed grate and moved from top to bottom as it burns. The temperature of the furnace is 300 °C In the furnace, there are tubes which are connected to the boiler.

The boiler is a two pass fire-tube boiler and produces superheated steam at a pressure of 14 kgf/cm^2 before entering the steam engine The main water supply for the boiler is provided by mechanical pumps which are attached to the steam engines and to the crankshaft. The mechanical

pumps will only work when the engines are in operation, as much, there is an electrical pump to assist the rate of flow of water into the boiler. The steam pressure from the boiler must not be below 11 5 kgf/cm^2.

Water supply system

The water for the boilers is supplied from a canal situated not far from the thermo-electrical plant. A pump is used to transfer the water into two tanks. The capacity of one tank is approximately 3625 gallons One tank contains cold water and the other hot water The water in the hot water tank is heated by passing it through a 7/8" diameter copper tube coil situated in the steam exhaust chimney The hot water is discharged into the boiler by a pump when required. The cold water is used for washing and disposal The boiler water is treated with chemicals to get rid of its impurities and its acidity. The water must have a pH value of 8.5 before entering the boiler.

Air control system

Above the boiler, there is a damper pipe that reaches into the combustion chamber and connected to a fan. This fan creates a suction through the damper pipe which draws air through the draft door at the bottom of the furnace and at the same time, pulls the fire and heat through the boiler tubes The air is discharged into the chimney to be released into this atmosphere.

Ash disposal system

The amount of ash produced by burning the husk is equivalent to 20% of the total husk burned Most of the ash is discharged into a pit at the bottom of the furnace with the aid of a trap door. The trap door is operated manually. Water is thrown into the pit so as to mix it with the ash for easy disposal A pump situated at the bottom of the furnace is used to pump the mixture (slurry) out.

The fan which is connected to the damper pipe collects approximately 1.5% of the total ash produced The ash is sucked through the furnace by the fan and passed through a cyclone to be separated from the combustion exhaust smoke. The ash from the cyclone is discharged into a pit in the base and mixed with cold water to be discharged by a pump to the point of disposal.

Steam engines

The steam engines are of the traditional type (horizontal) double acting They are designed for operating with steam of 14 kg/cm^2 (200 psi) and superheated steam temperature of 287 °C (550 °F).

On the steam engine there is a mechanical pump which is connected to a cam on the crankshaft. As the crankshaft rotates, the pump sucks and delivers water to the boiler. When the level of water in the boiler is maximum, a valve opens to return the water into the reservoir.

A gear pump is connected to the crankshaft by a belt. This pump is used to pump lubricants to the various areas that need to be lubricated. Copper tubes are used to distribute the lubricants. Situated on the cylinder head is another pump which lubricates the cylinder. The lubricant is then collected at the discharge and it is not to be re-used because of its contamination with

steam and metallic particles. This pump will only distribute lubricant when the steam engine is working. The lubrication system is checked every five minutes to ensure that the lubricant is flowing.

The speed of the engines can be regulated manually or automatically by a regulator that is on the steam engine.

Alternator–generators

As the flywheel on the steam engine rotates, the speed is transmitted to the pulley on the generator. The pulley shaft is connected to the generator shaft by a flexible coupling. The output of these alternator–generators is 440V

Electrical control system

The electrical power distribution is operated and controlled by a two-shift system over a 24 hour period.

Labour force

The labour requirement for smooth operation of the thermo-electrical plant per shift basis.

Activities	Labour force
Feeding husk	2
Ash disposing	2
Feeding furnace/boiler operators	4
Steam engine operator	4
Senior operator	1
Shift supervisor	1
Total	14

Power consumption

The power consumption of the thermo-electrical plant equipment is as follows:

• Husk feeding system	40 amps
• Ash disposal system	20 amps
• Water supply system	15 amps
• Air control system	40 amps
• Boiler feed pump	35 amps
	150 amps (maximum)

Cost analysis

Over a six-month period:

- Cost of power if supplied by GEC: $25 million (M)
- Cost of power if supplied by thermo-electrical plant: $5 M
- Cost benefit: $20 M
- Thus cost benefits per annum: $40 M

Apart from the above cost benefit, it should be noted that paddy husk or chaff being bulky is difficult to store and thus serves as an environmental nuisance. When burnt, the resulting ash, rich in organic content, can be composted and is recycled as fertilizer in the field and kitchen garden.

Status of the timber industry and the future trends and the availability of biomass fuel for cogeneration

L J P Willems, A A, Willems, Timber & Trading Company Limited

The experience of Willems Timber and Trading Company Limited, in the utilization of biomass fuel for cogeneration is presented in this paper.

The company has always had an association with steam power, starting in 1935 when a sawmill was established at Kaow Island in the Essequibo River. Because of its geographical location, Kaow Island has always had to generate its own power. The first mills were the old McDonald gangsaws manufactured in Scotland. These mills were a simple steam engine with a piston and a sliding valve mounted at the top. Steam provided the power to drive a sash connected to two flywheels. The steam was generated in simple wood-burning boilers which were hand-fed Of course, there were the attending pumps and steam mains. Also, there were steam winches which pulled the logs from the river into the mill. Other auxiliary equipment, such as overhead travelling hoists, were electrically driven with power generated from diesel generators. The mill grew over the years, and at one stage, five steam gangsaws of the type described were run, along with one circular diesel driven saw.

In 1952, the first steam powered generator was installed. This was a 250 KVA Belliss and Morcom steam generating set—a reciprocating steam engine which exhausts to atmosphere. There were numerous small boilers put in over the years The Belliss and Morcom set was found to be ideal, however, very wasteful. Steam generation became the main source of power from 1952, but the company was only on steam for approximately 65% of the time. Diesel stand-bys still played an important part.

In 1974, two wood-burning furnaces were purchased, which were redundant equipment, belonging to the Guyana Electricity Corporation (GEC). Subject to correction: these two steam boilers which were manufactured in 1924, were put up for sale by tender in February of 1974. The company took a hard look at it and decided that nobody would need a wood-burning boiler. However, the value of the firebricks, should pay for the cost of dismantling and removing, so the two redundant boilers were purchased. The year was 1974, and again subject to correction: in August of 1974, the oil crisis hit the world, causing severe increase in the price of petroleum products. At that stage, one of the Directors recognized a Pythagoras theorem and worked out that all the tubes of boilers, could be re-used, if the cradle of the drum was moved seven inches. This was done, and out of the two boilers, one slightly smaller boiler was rebuilt. This boiler increased the steam generating capacity, which brought up utilization of steam-generated current, to about 75%. However, the system was still inefficient with the Belliss and Morcom exhausting to the atmosphere. Enough fuel was not generated to meet the steam demands.

Between 1976 and 1979, the government made available to the timber industry, funds offered from the Canadian Government through their agency, known as the Canadian International Development Agency (CIDA). The company made use of this opportunity and by November 1984, the new steam generation plant started to give power. At this point, the fact that funding has always been a problem, and the installation of the condensing turbine, complete with package boiler, was a miracle of common sense engineering, should be brought to the forefront. If the normal route was taken, the economics of installing such a system, would not have been feasible

Originally, the tenders had gone out for a diesel generating set to run the mill. However, owing to government's policies and encouragement, CIDA was prevailed upon to allow the successful bidder to offer second hand equipment. CIDA contacted the unsuccessful bidders and no objections were raised. In this way, the company was able to put in a system worth several million US dollars for a fraction of the cost

There were problems of course. The consultant's design had three Dutch ovens feeding into a flue which conducted the hot gases into the package boiler. In order to compensate for inefficiencies, the package boiler had the capacity to generate 33 000 pounds of steam. However, the ovens proved to be a disaster, as all the fuel went into heating the ovens and the gas flue. The distance was shortened by cutting out one of the Dutch ovens The other two Dutch ovens were removed and, the gas flue shortened by about one-third. This was done successfully and all the efficiencies that are associated with a condensing steam turbine were enjoyed. The turbine, up and running, would start on Monday morning and be shut down after lunch on Saturday. The same volume of fuel had a far greater capacity for generation. This greatly enhanced the capacity, in fact, the company now generates an excess of waste. This development occurred at the end of 1984

The turbine is very efficient. But the method of waste handling is still inefficient. Only the hard waste and the shavings from the planning machines are utilized A lot less of the hard waste should be used as this could be utilized for further value added products, and also utilized instead for fuel, the sawdust and shavings, which would need to be dried by heat extracted from the chimney Nevertheless, the ratio of capital to what is achieved, is commendable.

In 1984, the company was told that it could not run a turbine, all sorts of engineering skills would be required. As recently as May 1996, a brief visit from an engineer with GEC of Britain, removed doubts when he made complimentary remarks on the smooth running of the turbine. During the period, there was one major hold-up for five weeks which was caused by the blockage of an internal lubrication line to a floating splined shaft.

By and large, the company has had nearly twelve years of excellent service from the turbine. Its weakness lies in the boiler capacity, this needs to be replace by the original second hand package boiler.

There are other points that should be noted, one being that Kaow Island, has very soft water. In fact, many visitors are amazed to know that the water is not treated. Many of the same visitors cannot accept the now proven fact that the river water at the location, does not need treatment.

So much more can be done, once capital, on soft financial terms, can be made available. The problem with alternate fuel always, is the high capital cost needed to put in an efficient unit, to make the best utilization of the waste. Provision of capital is the direction that the government should be considering, for it is quite obvious that the petroleum bills are exorbitant. Guyana has various volumes of material available, to be used for fuel in a cogeneration programme, although the initial capital expenditure may be high, cogeneration has a part to play in Guyana.

The company agreed to have the Institute of Applied Science and Technology of the University of Guyana, to come to Kaow Island to document its system. A consultant was retained through the help of the Caribbean Development Bank, and the results written up in what is now known as The Callendar Report, first drafted in 1988 with subsequent follow-up reports. There are some aspects of this Report which have been corrected in the system, since the actual study in 1988, such as the vacuum pressure achieved at the turbine. This, at the time of the study, read at 12, now it has been improved to a more acceptable 22–24.

One important aspect, of a cogeneration programme that should be explored, is the amount of machinary that can be fabricated in Guyana. Guyana spends a considerable amount on freight for ships which bring bulky equipment to its shores.

This equipment could easily be fabricated in Guyana with the design and engineering work done in partnership with local engineering firms, thus bring about savings for all concerned.

Effect of cogeneration on the power sector and the economy of the country

Leena Srivastava, Dean, Policy Analysis Division, Tata Energy Research Institute

I will speak about what I think are the major benefits that one could see for countries like Guyana and India, and finally on the energy demand forecast that we have for Guyana.

The affected parties that we are looking at are: industry, the electric utilities, the third parties who might benefit from the sales of cogenerated power as well as a better resource efficiency, and the society at large. I am not going to cover in any great detail the benefits to industry. Before we move to each of the sectors, let us take a look at the direct and indirect impacts of cogeneration.

The direct cost in benefits resulting from primary impacts of cogeneration systems are reflected in the saving and electricity sales, which are the primary benefits, and the indirect cost in benefits result from the secondary or tertiary impacts of cogeneration. One such example is that one might be able to write off a certain part of the production cost against the cogenerated power or that the company may have some revenue earnings also from the sale of cogenerated power.

From the utilities point of view, the primary benefit would be saving of power generation resulting from cogeneration. This is largely in the form of savings in capacity cost as far as the utility is concerned, and also in the fact that you may be saving a bit on reduced transmission and distribution losses since most of the cogenerated power would be available on site or close to site.

The secondary benefit is the fact that there is improvement in the reliability of power, the quality of power that is being supplied to the customer base that the utility has and other benefits related to reduced pollution and enhancement in national energy savings.

In terms of cost, I do not see any major cost to the electric utilities when they go in for cogeneration except for the amount the utilities would have to pay for cogenerated power and hopefully that should be less than the cost of generation including losses and the costs associated with losses due to transmission and distribution systems. I think as far as the utilities are concerned, they should be in favour of cogeneration systems.

The situations in which utilities need cogeneration can be narrowed down to; (i) a need for either cheaper sources of power or new capacity additions, and (ii) if a reasonable rate of return is allowed on the power that the utility buys from cogenerators. The first one is related to the economics of cogeneration and the second also relates to the economics but it is placed in a regulatory context in the sense that the prices are determined and there is a reasonable rate of

return that is allowed not only to the producers of cogenerated power but also to the utilities who are purchasing it. So it really has to translate into a win/win situation for both the parties.

If we look at costs and benefits to the society, there are more benefits than costs, and the benefits are quite obvious. The major benefit is increase in energy use efficiency and reduction in pollution from electricity generation.

The costs that are often listed against cogeneration to society is the fact that one may be diverting the use of limited resources and this could be financial or man-power resources to cogeneration, from other kinds of activities. This may or may not be applicable to all countries.

I think from the point of view of countries like India and Guyana, the major benefits that I see from cogeneration are that we are able to avoid the transmission and distribution losses which can be very significant and I think that Guyana also has Transmission and Distribution (T & D) losses in the range of about 30%, which includes probably, as in the case of India, some commercial losses or thefts, which again is something that could be avoided if you are using cogenerated power. The second major benefit is an overall improvement in resource efficiency and this is particularly true also for the developing countries where you have a constraint on the natural resource base that is available and the financial and technological resources that are at your disposal for exploiting these natural resource bases and cogeneration is an efficient utilization of energy and by cogeneration you are also implying improvement in the efficiency of the utilization of your financial resources, and environment in particular.

The other major factor associated with cogeneration is a mobilization of investments In a situation like India, for example, so far supplying energy and electricity in particular, was the responsibility of the government. Especially the public sector, that was responsible for supplying the electricity. They were responsible for mobilizing the resources for adding to capacity for ensuring adequate T & D systems and so on. In the instance where one has cogenerated power, one is moving from primarily public investment to a greater level of private investment in the generation of electricity in the system.

Finally, there is the most major benefit of reduced imports which applies to Guyana as much as it does to India. I am sure there can also be several more benefits and any inputs that we have over there would be quite welcome. But I did take a look at the Energy Policy document that was prepared in Guyana and while it was very useful, I had a couple of questions which would have an implication on the total electricity demand projections that you have for Guyana and therefore the role of cogeneration and other biomass generation that you might have. If you look at the overall energy situation, there is a consumption level in Guyana to date of roughly 800 kilograms of oil equivalent (kgoe) per capita and if you compare that with the world average which is in the range of about 1500 kgoe per capita, we still have in Guyana a long way to go to get to the world average situation. If one takes that as an indicator of lifestyles or development, then as a country I would think that one would want to aim for a much higher level of consumption while at the same time acknowledging that the efficiency with which energy is consumed can also be improved.

So if you look at the projections which are really based on several assumptions that have been listed in the policy document, one of the things that has been said is that consumption of energy

by the residential sector must be in line with population growth. Now if that assumption is made, I think implicit in it is the fact that you remain at the consumption level and therefore the lifestyle levels that you have today, and also implicit in it is the fact that there may be a certain segment of the population that does not have access to adequate energy supply. So the situation of shortages is really something that you are projecting into the future.

The second was it seems that the GDP/GNP growth that we are really looking at is in the range of 1.5 to 2% per annum which again seems to be rather conservative and like I said earlier, the reason why I am raising some of these question over here is that it does have an implication on total electricity demand and therefore the role that cogeneration can play.

Session III

Cogeneration technology based on biomass from sugar, rice, and timber industry

Technical options and cost implications for producing surplus power from sugarcane bagasse

Marlan J Mitch, FC Schaffer & Associates, Inc

Most sugar mills are designed to have an energy balance which does not result in the production of excess bagasse, as it very quickly becomes a disposal problem. Thus, factories are normally designed to produce only that power which is required for its own operation or estate usage (a mill will normally be designed to produce an excess of approximately 10% bagasse to cover normal starts and stops). A mill can be designed or modified to produce bagasse in excess of its requirements for use in by-products (particle board, furfural, paper, animal feed or other uses) relatively easily or to produce excess power. In the past, most mills were designed so that they only produced the power that they required and only in a few exceptions were they designed to produce excess power for sale. With today's increasing demands for additional electrical power, concerns for reduction in fossil fuel usage and reduction of expenditure of foreign exchange, design or conversion of existing sugar mills to be producers of surplus power is becoming more viable and attractive to the mill owner. In this discussion, some of the technical options which are open to the mill owner for the production of surplus power and the cost associated with this power production are discussed

For this discussion it is assumed that one is speaking of a mill with a crushing capacity of 5000 metric tonnes crushed per day (MTCD) and is capable of producing its own energy requirements. Generally speaking, a properly designed sugar factory processing medium fibre cane (14–15%) can produce approximately 4–6 MW of surplus electric power per 1000 MTCD. If the factory is new and is designed to be a cogenerator of electrical power, there is little additional cost associated with this ability beyond the installed cost of condensing or condensing extraction turbo-alternators In studies performed recently, this additional cost is approximately $350 000/MW

To obtain this increase in power production, at an existing factory, often requires major factory additions such as the replacement of existing boilers, the installation of additional process equipment (heaters, evaporators, pans, etc.) and modifications to the piping and electrical systems To achieve this increase in power production, the cost of these modifications are typically $1 25 to $2.00 million/MW While this is sometimes economically justified for the country, it is often not financially attractive to the sugar company However, lower amounts of power can often be obtained for very little to moderate capital expenditures. Before any factory considers cogeneration of electricity for supply to a third party, the factory must become self-sufficient in its own fuel and electrical needs. While this is a relatively simple task for a sugar mill, it has been found through the years that approximately 10% of the factories have had to purchase auxiliary fuel, electricity or both on a continual basis. This in itself produces a financial drain on the company and imposes a reliance on outside suppliers. This 10% excludes factories that sell their baggage for paper, furfural or other purposes. If a factory has been designed to be energy self-

sufficient, it can eliminate the need to purchase fuel and/or electricity at nil or moderate cost by simply reducing their lost time.

In about 755 of the over 2000 factories for whom the company has performed material and energy balances it has been found that 1 or 2 MW per 1000 MTCD of additional power could be obtained for no or very little cost.

Prior to discussing the technical options which are appropriate to the sugar industry and their associated costs, the most important step in the development of a cogeneration project is discussed. This is the development of a well thought-out and planned programme which begins with a thorough investigation of the existing facilities and what these facilities are capable of producing. To achieve this, a modern computerized material and energy balance which takes into account present and future operating conditions needs to be utilized The use of a computerized material and energy balance allows one to look at many scenarios of variations in operation, equipment, and cane quality in a short time to arrive at the optimum arrangement of equipment and material. Now, optimal operating conditions can be arrived at without wasting time. Most of the time is now spent inputing the basic data to the programme Now a good plan, for eliminating fuel and electricity purchases and obtaining various levels of electrical power for sale, can be performed in a matter of days. The programme which has been developed will give a printout of all major equipment required in the factory, all process flows, and a detailed energy balance

There are basically five options open to a sugar mill designer or mill owner for an existing factory to produce excess power These are.

- installation of a full condensing turbo-alternator with the same operating pressure as existing equipment,
- installation of a back-pressure turbo-alternator with the same operating pressure as existing equipment,
- installation of a higher pressure boiler to burn excess bagasse and full condensing turbo-alternator operating at this higher pressure or a 'topping' turbo-alternator exhausting at the existing live steam pressure,
- installation of a higher pressure boiler to burn the factory's full production of bagasse and extraction/condensing turbo-alternator operating at the higher pressure and extracting at the present operating pressure, and
- installation of a higher pressure boiler to burn the factory's full production of bagasse and installation of all new high pressure multi-stage (or electric motor) prime movers and extraction/condensing turbo-alternator

Programmes in which these options would be utilized are as follows

1 Improve factory operations without capital expense Subjects that need to be addressed are.
   a Lower unscheduled lost time to five per cent or less This will usually not only eliminate the need to purchase auxiliary fuel but will often increase the yield of sugar substantially by up to 10% for factories with high lost time (25–30% and more) through the elimination of inversion losses, liquidation, ditching of juice, pumping out of molasses, etc. It is very unlikely that cogeneration will be successful if the sugar factory has high lost time

as it will be necessary to burn some form of auxiliary fuel during times of outages and start-ups

b. Improve cleanliness of cane by starting in the field with good supervision of harvesting and loading. Elimination of field soil at the source reduces wear on the factory and improves the burnability of bagasse Also cane washing can be used, but it requires power for pumping
c. Properly set mills Adjust mill settings at least weekly, arc rolls all with the objective of lowering bagasse moisture (at the same time improves extraction). Each full point reduction in bagasse moisture will result in approximately ½ % gain in boiler efficiency (one per cent more steam)
d Eliminate air leaks in and around boilers, preheaters, and ductwork, also eliminate open bagasse feeders
e. Reduce amount of excess air in boiler. The amount of excess air required for complete combustion of bagasse will vary from area to area but should be in the range of 30 to 50% excess air An excessive amount of excess air results in loss of heat and a corresponding drop in boiler efficiency
f. Check proper operation of de-aerator, induced and forced draft fans, etc Eliminate excess boiler blowndown by using good feed water and chemical treatment Installation of a de-aerator in a plant which does not have one can result in a gain of steam capacity of up to eight per cent Checking proper operation of the fans ensures that the proper amount of air is flowing to the boiler at the required pressure and volume. As excess air is important for combustion, insufficient air is just as important as incomplete combustion and will reduce the efficiency of the boiler. For each one per cent increase in carbon monoxide, in the flue gases, represents a 4.5% heat loss due to incomplete combustion. Decreasing the blowdown will also effectively increase its capacity
g. Eliminate steam loss through defective traps, steam leaks, worn ejector nozzles, etc In many factories, nozzles on steam jet ejectors are worn and are consuming up to twice the normal amount of steam necessary Leaking or inoperative steam traps allow the system to loose steam at rates which may surprise most operators.
h. Reduce losses in electrical system by better control of the turbo-alternators, improving power factor, reducing line losses, improving diversity factor, etc
i Conserve condensate—return first condensate to the de-aerator under pressure to retain its heat, return second condensate to testing tank and test for presence of sucrose and store in an excess condensate tank for use in the boilers, insulate all condensate lines Each 5 °C drop in feedwater temperature represents approximately a one per cent drop in the steam production capacity of the boiler plant.

Under this scenario it has been found that up to 20–40 tonnes per hour of steam can be saved This steam would be utilized in a full condensing turbo-alternator (option 1), of the same operating pressure as the existing system, and can deliver up to approximately 4–8 MW

A variation on this scenario is to produce additional steam by adding cane washing equipment and air preheater surface to bring stack temperatures down to 200 °C This additional steam, passed through a condensing turbo-alternator, will often provide around 5 MW of power. If there is high ash content in the bagasse due to contamination from harvesting techniques, the installation of a cane washing facility can remove a substantial amount of ash in the form of field soil and/or sand For each one per cent that the ash is reduced can represent an increase of about

0 5–1% steam generating capacity. Installation of an air preheater on a boiler which does not have one can result in an increase in steam production of approximately 5–10%.

Another variation of this scenario is to modify the evaporator scheme to make it more steam efficient or perhaps install vapour recompression. The steam saved in this case could be passed through the condensing turbo-alternator. It is possible to achieve 3–5 MW from this option.

- If the factory is regularly making up live steam to exhaust, this steam can be passed through a back pressure turbo-alternator. Many factories make up 20–40 tonnes per hour of steam. This represents an additional 2–4 MW of power This scenario would be used with option 2.
- In this programme, the bagasse gained from the improvements in operations or harvesting methods would be burnt in a new high pressure boiler and the steam consumed in a full condensing turbo-alternator or a "topping" turbo-alternator exhausting at existing plant steam pressure. This scenario would be used as option 3 and can result in an increase of 5–8 MW.
- The next programme, would be to install a new higher pressure boiler which handle the entire bagasse production/condensing turbo-alternator Under this scenario, option 4, it is possible to achieve gains in power production of 25–35 MW. It may also be possible in this case to install bagasse dryers or continuous vacuum pans to further improve the steam efficiency of the factory. It is more prudent to install air preheaters as they have no moving parts, are simple to install, and maintain. Bagasse dryers are expensive to install, operate, and maintain.

This option may be the most viable for an existing sugar mill This is the approach which has been found to be the most popular in the recent past

A particular project has a very large outside storage system which is a requirement of the client. The installation is a 30 MW plant which will provide 107 tonnes per hour of steam at 21 bars back to the adjacent sugar factory and 22 MW of power to the public service grid The plan will require the installation of two 136 tonnes per hour boilers operating at 62 bars and 538 °C.

- The last programme would be to rework the entire factory to install high pressure boilers and new high pressure prime movers. New turbo-alternator drives would be installed in addition to condensing or extraction/condensing machines In this option 5, an additional 35–40 MW could be gained This option increases the cost of a project as the process may have to be modified to take into account less exhaust available for process heating and may require more process equipment. Also, the installation of high pressure piping throughout the plant greatly increases its cost due to material cost, installation cost, X-raying, and heat treatment of welds In speaking of the installation of higher pressure boiler, it is necessary to address the additional efficiency gained by utilizing a higher steam pressure and temperature in the factory

Utilizing a higher steam pressure and temperature can result in significant gains in power production capability Increasing the generating pressure and temperature does produce gains in potential production of kilowatts but results in a decrease of actual tonnage of steam produced. It requires more heat per kg of steam produced and it also requires more kW per tonne of bagasse burnt to produce this steam Additional power is consumed by higher power requirements in feedwater pumps, fan drives, and cooling water pumps if a condensing turbo-alternator is in-

stalled The greatest gain in power production is realized in going from a lower generation pressure and temperature to approximately 45 bars. Above 45 bars the incremental gain drops significantly Further, once one exceeds 45 bars problems of feedwater conditioning and boiler water maintenance become very critical. Operation of a boiler of this nature requires skilled operators and maintenance staff which are usually not available in cane growing areas. Operation of a higher pressure boiler also increases the chances of a serious accident which at these pressures can be catastrophic. It is not recommended to a client to exceed 45 bars.

The options discussed above, are most viable to an existing sugar factory utilizing their available bagasse supply. These are the most viable from a financial standpoint. Other options such as firing additional fuel oil or agricultural wastes are also possible.

In performing any modification, modernization or expansion there is a capital cost which has to be addressed and it is one of the most important items which will determine if a project is financially viable This cost in conjunction with other factors will determine if a project will proceed or not

Capital cost of a project, while being site specific, can generally be broken down into cost of equipment, freight, construction activities, and engineering. There are many factors to be taken into account particularly location and availability of local construction labour. A general rule-of-thumb is that a project will cost between two and two and a half times the initial cost of equipment This not only means the cost of the major items of equipment but all equipment required to support that major item such as buildings, pumps, conveyors, piping, electrical equipment, etc.

In the options shown above, the turbo-alternators and boilers are the most expensive items which have to be purchased and have the longest delivery times. If one wishes to place a project on line quickly or at a lesser cost then the use of secondhand (used) equipment should be considered However, when employing used equipment, one cannot estimate the final cost of the project on a multiple of the used cost but rather the new cost must be used. The use of used equipment when practical is recommended. One can normally find a good used boiler for a client However, many times it is necessary to retube, replace duct work, refractory, insulation, casings, etc When this has to be done the cost of a new boiler is not much more than that of a reconditioned unit

If a project is to be financed by a local or international lending institution, they will, in all probability, require that the borrower purchase new equipment In many cases the lending institution may have restrictions as to where the equipment is acquired. The United States Export Import Bank requires that all equipment which it finances be purchased within the United States This is true of most, if not all national lending institutions. International lending institutions normally require that the borrower purchase from a list of countries which are members of that institution.

In the case of cogeneration at an existing sugar factory, the main items of equipment which are required to be installed are back-pressure, condensing or condensing/extraction turbo-alternators, surface condensers, and boilers. The cost of mechanical equipment of this nature is influenced by materials of construction, country of manufacture, prevailing market conditions,

method of sale, location of installation, after sales service requirements, and various other factors. To give the participants at this seminar an idea of cost of these items of equipment, the following budget costs are presented from American manufacturers of turbo-alternators and bagasse fired boilers. (Tables ' and 2)

The costs as given are indicative of the major items of equipment but do not give one a sense of the cost associated with each of the technical options given previously However, the following ranges of cost for each option are developed.

Option no 1—full condensing turbo-alternator operating at same steam pressure of existing factory. $ 300 000–$ 600 000/MW.

Option no 2—back-pressure turbo-alternator operating at same steam pressure of existing factory: $ 250 000–$ 500 000/MW.

Option no. 3—higher pressure boiler and back-pressure or condensing turbo-alternator: $ 900 000–$ 1 300 000/MW.

Table 1. Cost of turbo-alternators

Size (MW)	Steam conditions	Approximate cost (US $)
	Back-pressure units	
1	31 bar/343 °C/1 4 bar	140000
2 5	18 bar/341 °C/1 25 bar	615000
3	23 bar/326 °C/1 5 bar	625000
4	41 bar/315 °C/6 9 bar	720000
	Full condensing units	
2 5	17 bar/260 °C/100 mm HgA	650000
5	17 bar/260 °C/100 mm HgA	900000
2 5	45 bar/260 °C/100 mm HgA	650000
5	17 bar/260 °C/100 mm HgA	825000
10	17 bar/260 °C/100 mm HgA	3100000
20	45 bar/260 °C/100 mm HgA	3900000
10	45 bar/260 °C/100 mm HgA	2900000
20	45 bar/399 °C/100 mm HgA	3900000
	Extraction-condensing units	
10*	45 bar/399 °C, 17 2 bar, 1 4 bar, 100 mm HgA	2900000
20*	45 bar/399 °C, 17 2 bar, 1 4 bar, 100 mm HgA	3750000

Extraction is uncontrolled For controlled extraction add $ 250 000 per unit
Note Delivery time—1–5 MW units 12 months, 6 MW and over-14–15 months

Surface condenser with air evacuation set

Size	Cost, US $
10 MW (45 4 TPH)	160000
20 MW (90 7 TPH)	275000

Table 2 Cost of boilers

Size, tonnes	Pressure (bar)	Temperature (°C)	Approximate cost (US $)
	Tube and tile construction		
34	21	399	1700000
45	21	399	1850000
57	21	399	2000000
68	21	399	2300000
	Tube and tile construction		
34	41	399	1813000
45	41	399	1980000
57	41	399	2140000
68	41	399	2800000
	Membrane wall construction		
113	17	343	6600000
113	31	349	7425000
113	45	370	7700000
113	59	386	7975000

Note Delivery time—tube and tile construction-12 months, membrane wall construction-12–14 months

Option no 4—Higher pressure boiler burning entire factory production of bagasse and extraction/condensing turbo-alternator. $ 1 500 000–$ 2 000 000/MW.

Option no. 5—Same as option 4 but install prime movers with higher operating pressure: $ 1 800 000–$ 2 500 000/MW

In summary, a 5000 MTCD sugarcane mill can usually achieve an additional 5–15 MW at a relatively low cost of approximately $ 500 000 per MW through improvement in operation and energy saving steps and this cost may be lowered to approximately $ 300 000 per MW with good used equipment. Beyond this range, however, production of additional megawattage becomes very costly with each additional MW costing $ 1 000 000–$ 2 000 000

Cogeneration and energy efficient technologies pertinent to sugarcane

Guyana Sugar Company

Mr Mitch has already covered the technicalities as well as the technologies involved. I would like to go into some more detail and try to give some figures on what can be done and show how those figures have been calculated and how the 8–10 MW target can be achieved.

One of the points that I'd like to take from Mr Mitch's presentation is what he said about cogeneration potential—low lost time He talked about 5–10%. Now, 5–10% of 168 hrs a week is between 8–16 hrs per week lost time. Ideally, we should be operating between 152–160 hrs per week The reality is that in Demerara we are operating for 107 hrs per week, that's two days less than what he is suggesting per week and in Berbice, 125–130 hrs, which is a full day a week less than what is one of the prime prerequisites for cogeneration to be successful. That creates a major problem in achieving the 10 MW that we are talking about

Let me take you through how a sugar factory and an energy balance works in a factory. I'll take 100 tonnes an hour as the base case. That is 3 1/2 thousand tonnes a day design capacity which is being run in Blairmont In Rose Hall, it is slightly more, and slightly less in Skeldon.

In a typical factory, with 100 tonnes of cane 15 tonnes of fibre an hour are put into the mill. For a boiler efficiency is of 62%, which is about top end of the wire for the boilers which are being run in Guyana at the moment, it is slightly less than the converted boilers being used now. We would expect to produce 2 4 tonnes of steam and end up with 72 tonnes of steam potential coming out of the boilers

Now, let me just draw out briefly how a factory is worked If one takes high pressure steam, it will either go to the turbo or it goes to a number of turbines What I am saying is that those potentials are there in the industry. We have done heat balances for all the factories under the development programme In trying to do the programme as cheaply as possible, we are getting an imbalance in the bagasse situation. The production is anything from 1 7 MWs, at the factories that we are reinvesting in—up to 3 MW at Rose Hall where the fibre percentage is relatively high and we working to get it down because of the problems of extracting and the economies of taking out that extra sugar

GUYSUCO does not have the plant operating hours being discussed here. The factory time efficiencies that Mr Mitch mentioned are not factory reliability problems. We are achieving 95% and 92% at first in about all the estates without exception. The problem is 'out of cane' and that is taking place for a number of reasons—industrial action, weather, and other reasons. The reality is the problem lies outside the factory.

So, in effect, there are no problems where there is a concept of factories putting in condensing turbines to back up the process and mopping up the excess that is being generated and will be generated in the redeveloped factories. The first factory to be redeveloped is Skeldon factory To keep costs to a minimum one of the existing boilers has to be kept. It is operating now at 180 psig but is designed to operate at 250 psig. So there are two options there, either go for another new boiler operating at 250 and generate the 2 MW/1.7 MW or just put a condensing set and go for a higher pressure unit and the pass out condensing set that tops off into the system

This means that we have to move from this pan floor requirement of 65% on steam towards the 53% on steam We are putting in a new pan loft because the old one is a wooden structure It has got 1920 pans. It is an opportunity to move to a more modern panboiling system The problem comes where the technology applicable for the resource that you have is recommended is to be managed in that environment. Computer control of pan floor could be recommended in set-up but our instructions are, minimum cost in terms of price. We cannot justify those extra costs over a standard operated pan floor. Therefore, we can't suggest that we could get anywhere near the 47% on steam.

GUYSUCO has had big problems recruiting engineers and getting instrumentation to work There has been a phenomenal resistance to instrumentation, mainly from the operators because they are afraid of loosing their jobs and that they will be replaced The same problems have gone through Europe and British sugar when we tried to compensate and import computerized panboiling in 1981/82. We faced big problems with the panboilers. It took us three years to get through this culture problem.

Skeldon is the first project to have computerized panboiling and sophisticated control. Therefore, Skeldon should go for a 'tag-on' cogeneration situation, 2 1 MW, 2 MW into the grid and get the experience of operating it.

Rose Hall factory would be the next big project. We thought about taking it from 95 tonnes an hour to 115–130 tonnes an hour On that estate we are recommending that the boilers be totally replaced. This is where we have an opportunity We can go to different stages of pressure The question is—how far do you go on stage 2 of your development? We are operating up to 250 psig boilers here.

I'd like to talk about the risk of operating high-pressure boilers of about 250 °C Those boilers don't need water treatment. They are only operating with 50° of super heat Pressure is insignificant in the equation. The only reason the pressure is increased in these boilers is to reduce the volume of the pipe works, the control valves, etc. Super heat is the key to all the problems of cogeneration.

We could move up to 30 bar boilers with existing manufacturing technology We are up to 325 °C there, we don't use special steels and don't have to replace turbines We can get away with water treatment, deionizing plants, etc We don't need sophisticated problems with high pressure boilers We are only talking about 100° of super heat It is within the confines of mild steel technology We don't have to use high chromium steels

The other option is to move to the next step, i.e. bar boilers, 400 °C, 450 psi, 125° super heat. Let me give you some examples of the problems we are facing at the operations at the moment

We had vibrations in a turbine at Albion. When the engineers came they found the drains from the water separator which should only separate spots of water, blocked with mud which means that there was massive carry over, and the boilers were full of mud. The laboratory hasn't been in control of the TDS figures There is nothing wrong with the TDSs and the pH. I cannot therefore recommend that we go anywhere near 60 bar boilers at the present time. For stage two, we should confine ourselves to 30 bar and then do what we can within the factory, given the fact that the factory does have constraints on cash. We do what we can to bring this figure down to 55–54 and then go for some form of cogeneration.

One problem is that Berbice runs at 60 cycles. Therefore, the logical thing to do would be to actually put in a turbine that runs on 60 cycles for the grid and use your own turbine to power your factory and dump into the grid Rose Hall is 1 mile down the road and has a 13.8 kV line down the road It can generate at 13 8 kV and drop it into the grid. But we are not really talking about the 7 MW We can get the time efficiencies up we go to 4–5 MW GUYSUCO should consider this in the background The industry must rehabilitate itself first, it contributes 28% gross domestic product (GDP) Cogeneration needs long operating hours. We have industrial relations problems at Rose Hall, probably more than the ones at any other estate in Berbice, on the cane cutting side We are addressing that by changing varieties, so that the punt weights can be put in This means that the fibre in cane is going to drop from 18 4 to 15.7 because the investment put into the factory have to be recovered It has to be justified on a sugar revenue basis because that is what the board has told us

We also have to add up to 272–280% inhibition on cane and that unfortunately cuts considerably into this 47/55 situation. We are going for the shredders, and put the inhibition in to justify the expenditure.

The other point on technology is the energy value in bagasse We have seen figures put on 47% moisture, those bagasse moistures will be achieved on a 6 mill tandem and probably at 200% inhibition on fibre or thereabouts In the rehabilitation of GUYSUCO we have seriously looked at how many mills we put in the milling tandem, and the cost benefit analysis in terms of sugar revenue We can't justify any more than four mills—a mill costs US $0.5 million, plus ancillary equipment that carries the cost to US $0 6/0 7, so two mills will cost US $1.5 million. We cannot get the extra revenues back on sugar extraction because in Guyana there is a low-purity cane and a low poll cane which is different from many other places like Hawaii and India to a certain extent, with successful cogeneration projects going on The purity in the juice in India is 84–85% mixed juice purities.

All these figures I've been talking about are based on 2.4 kg of steam per kg of bagasse that is about 62–63% boiler efficiency The highest boiler efficiency on bagasse is 68. That might move from 2.4 kg to 2.5 kg

In summary, GUYSUCO is trying to be practical and realistic We have to rehabilitate the industry to keep the factory time efficiencies where they are. We cannot carry on running poor quality equipment. The mills have to be in good condition Skeldon, Blairmont, and Rose Hall are getting new mill houses because those are running with worn out equipment There are very logical developments that we can follow and I think we can, through those developments, learn to develop the technology, develop the knowledge base and progress to the next stage.

Session IV

Institutional and related technical issues in cogenerated power generation and distribution

National grid interfacing and grid management issues

Guyana Electricity Corporation

My presentation concentrates generally on the concerns that GEC would have, as it relates to additional generating sources, be it through cogeneration or otherwise. The first and primary issue would be the location of the generating set as it relates to increases in costs in terms of what is required, how many utility poles need to be planted, and the length of the hook-up line to our grid system.

Secondly, the operating frequency would be of primary concern, as we have a dual frequency system in Guyana There is no way practically and in theory that you can link the two systems directly only through convertors. The operating voltage is also of primary concern to us where we require stable voltage generation. Harmonics would result in disturbance to our complete national system and would eventually result in increased suffering of the consumers.

Power factor control is also of concern and protection of the system unit. The cogenerator should coordinate with the protection scheme of our system as the interconnected system would be of concern We'd be interested in the level of continuous power that could be guaranteed to us for purpose of distribution as well as the mechanism that would be put in place for system communication and operational directives

As you are aware, we have generating sets located at Anna Regina, Bartica, Versailles, Garden-of-Eden, Tungsten, Sophia, Onverwagt and Canefield These generating sets are not totally interconnected because of geographical restrictions. However, the Tungsten power station is connected to the convertor station at Sophia via an 11 kV inter-connector. Now, we have a transmission line between the Indian sub-station and the Garden of-Eden sub station There is another transmission line between the Garden-of-Eden sub-station and Sophia sub-station, then there is a break in the transmission link and the transmission line continues at Onverwagt to Canefield up to No. 53 on the Corentyne. In the absence of the transmission line between Sophia and Onverwagt we have a 13.8 kV feeder as the transmission link between the two stations

In the event of a cogenerator set being planned, it would be prudent to position these sets in close proximity to the existing lines, so that costs can be reduced considerably. Our power distribution is 11 kV voltage levels in the 50 Hertz areas and 13 8 in the 60 Hertz areas. It therefore becomes important for the cogenerator, whether he is generating at 115 V or 460 V, to select suitable systems like the transformer and its related equipments before hooking on to the grid.

For power factor control, we would need the cogenerator set to have a strict control of the system power factor because the generation will have an impact on the overall system. The power

factor will determine the amount of current being consumed Also, it will indirectly indicate the relationship between the current loading of the system and its reliability.

The cogenerator systems should be protected And, the operation of the cogeneration plant must be coordinated in a time sequence with GEC There should be protection schemes at GEC's power stations so that faults can be isolated and reduced to a minimum geographic area.

The cogenerator would need to coordinate activities with the GEC in terms of system communication and operation directives They would be taking instructions from our systems' control department, if it needs synchronizing stations, or taking cogenerating stations off or regulating the load at different times of the day

We would also need to have a guaranteed minimum level of generation, that we can rely on, for our distribution planning purposes

Session V

Financial, economic, and legal aspects

Financing of cogeneration projects

Pradeep Dadhich, Tata Energy Research Institute, New Delhi

Economic considerations

Steam turbine generators can help save substantial amount of energy in cogeneration systems. However, these plants require greater capital expenditures than plants which supply only low pressure process steam This incremental capital investment must be justified by the reduced annual operating costs Generally, a capital budgeting decision analysis is made to determine if the venture meets the company's requirements for returns on investment or payout. Likewise, any additional investment for a larger or more efficient cogeneration alternative *versus* a smaller system must also meet management's requirements for returns on investment or payout

The first step for an economic evaluation of cogeneration systems is normally to determine the course of action, which involves minimum capital expenditure This is the *base case*. For a new plant, this would be low-pressure boilers for process heat and no cogeneration For an existing plant, the base case might be the do-nothing alternative.

Several cogeneration alternatives might be proposed. These might include various throttle pressures, the use of a condensing section, or a combined steam and gas turbine. The base case and the cogeneration alternatives should then be developed to determine the estimated performance data and equipment ratings. The next step would be to convert these data into terms of cash, i.e., initial investment cost estimates for each alternative and annual operating costs. When these data have been developed, a return or payout evaluation is made. If several cogeneration alternatives meet management's capital budgeting criteria, then each increment of additional investment should be evaluated. The final decision would be to select the alternative with the highest increment, which meets the return or payout criteria.

Investment cost data

The incremental investment costs due to cogeneration should be the focus of evaluation of a cogeneration system The incremental cost data represent the differences in cost between a low pressure process boiler plant and a cogeneration plant with steam conditions of 60 bars, 415 °C turbine inlet, and a 3 5 bar exhaust. All cases include 50% spare boiler capacity. The low-sulphur coal and residual oil include costs of the particulate removal system.

It has to be noted that these costs exhibit a substantial economy of scale penalty for plant sizes less than 90 tonnes/hour. In larger plant sizes, the incremental investment costs are Rs 300 000–360 000/kW, with an additional Rs 450 000/kW added for dust collection systems.

Investment costs in terms of Rs/kW will vary significantly with steam conditions For example, a 15 bar process pressure, instead of 3.5 bar, would increase investment costs by approximately 50%.

Annual operating costs

The focus of developing annual operating costs should be on any differential costs due to cogeneration. Normally, these include costs of fuel, power, labour, maintenance, cooling water, and boiler make-up water

To illustrate these calculations, evaluations of a 160 tph plant size have been made for residual oil and coal In addition to the 60 bar cogeneration system, plants that throttle pressures of 85 and 100 bars have also been considered. The premises used in evaluating annual operating costs are shown in Table 1

An example of the calculation of annual operating costs for a residual fuel case with a purchased power rate of Rs 2.25/kWh is shown in Table 2 Also included in this table is a summary of calculations of gross payout However, discounted rate of return (DRR) is given on the incremental investment for cogeneration cases Gross payout is defined as.

$$\text{Gross payout} = \frac{\text{Incremental investment}}{\text{Gross annual savings}}$$

The DRR calculations can be made using the after-tax discounted cash-flow analysis method. The parameters used in these calculations are·

- income tax rate—50%;
- depreciation—28 years, sum-of-the-years method,
- investment life—25 years, and
- local taxes and insurance—2 5%

The typical minimum acceptable DRR values for industrial firms are in the range of 15–25% All three cogeneration alternatives mentioned earlier would pass such a criterion The next step would be to determine DRR values for the incremental investment for the higher pressure cases against the 60 bar cogeneration case For some companies, the higher pressure would have an acceptable return; for others, it would be unacceptable

Another important parameter not illustrated here would be the PLF When a cogeneration system is operated at base load to serve continuous heat and power requirements, it generates maximum savings in annual operating costs When the cogeneration system serves non-continuous loads (5 or 10 shifts per week) and/or seasonal cyclic loads, the annual savings will be diminished. Therefore, cogeneration systems in these applications are more difficult to justify.

Financing cogeneration projects

Cogeneration projects generally involve investment in capital equipment to produce electricity and thermal energy Such investments produce revenues from the sale of electricity and thermal energy, or reduce the operating costs for the purchase of such energy The financing of a cogeneration project is, therefore, similar to the financing of any capital-intensive project Revenues from the sale of products from the cogeneration project (or the cost reduction resulting from the

Table 1 Premises of economic evaluation of cogeneration plants

Category	Premise
Annual operation	8400 hours/year
Fuel costs	
Residual oil	Rs 6 50/(10 000) kcal (HHV)
Coal	Rs 1 25/(5500) kcal (HHV)
Purchased power cost	Rs 2 25/kWh
Annual maintenance cost	2 5% of investment
Operating labour	
Process boiler cases	Base
Cogeneration cases	Base + Rs 9000000/year
Plant size	160 tph process steam load

Note Cost data for a hypothetical case

Table 2 Summary of annual operating costs and an example of economic evaluation of cogeneration plants

Annual operating costs	Base case	60 bar	85 bar	100 bar
Fuel consumption (Gcal/hour)	120	144	150	153
Net power (kW)	(440)	23720	29500	31600
Annual costs (Rs in lakhs)				
Fuel	6549 38	7864 75	8197 73	8349 08
Power	83 16	(4483.08)	(5575 50)	(5972 40)
Labour	Base	10	10	10
Maintenance	9	11	12	12
Total	6641 54	3432 67	2644 23	2398 68
Annual savings	Base	3208 87	3997 31	4242 86
Gross payout (years)	Base	2 22	2 21	2 23
DRR (%)	Base	—	—	—

Note Figures in parentheses indicate earnings due to export of surplus power to the grid

use of these products) must be sufficient to provide for the operating expenses and produce sufficient returns for the investments made in the project by the financing sources.

General considerations

While cogeneration projects exhibit a tremendous diversity in project size, scope, ownership, financing method, and the amount of financing required, the following issues must be considered in developing the optimum financing approach.

Credit worthiness

What is the credit rating of the various parties involved in the cogeneration project, and what is their capability to generate the necessary financing?

Type of financing

What are the different possible methods for financing the project, and what could be the roles of the various parties in developing the financing?

Financing sources
What are the major sources for the funds required for the cogeneration project, and what portion of the total funds will come from each source?

Risks and risk sharing
What are the major financial risks presented by the cogeneration project, and who will share the risk and in what proportion?

Ability to utilize tax benefits
Can project participants take advantage of the available tax benefits, and what is the optimal allocation of tax benefits to the various participants? This might be beneficial under the New Economic Policy

Requirements of financing sources
What requirements will the major financing sources impose upon the project, and how can these be satisfied?

It is important for project developers to pay adequate attention to all these issues in order to develop the financing plan, which will provide adequate resources for the project and sufficient sharing of risks and benefits to the various project participants

Financing sources

Although there are several industrial financial institutions, financing of cogeneration projects requires some special considerations such as cogeneration co-developers and build, own, operate, and transfer (BOOT)/build, own, and operate (BOO)/build, operate, and transfer (BOT) schemes Cogeneration project developers (these may include engineering firms and/or equipment suppliers) will find that a number of different sources are available for financing their projects Projects may be financed exclusively from one of these sources, or through a combination of different sources It is also important to recognize that some of these financing sources will provide equity financing as well as debt to the project An evaluation of which financing source would be the most appropriate for a particular project depends on the type of financing commitments, the terms of financing, the size of financing required, and the approach of the financing organization to risk containment and risk sharing A discussion on some of the common financing sources is provided below

Commercial banks
Commercial banks are likely to be one of the most common sources for financing cogeneration projects In particular, medium-to-large commercial banks are increasingly interested in alternative energy projects and are now convinced that cogeneration projects are attractive for conventional bank financing For large projects, banks may form a consortium to develop the needed financing The terms and conditions of commercial banks can vary significantly from project to project, and may include fixed or variable interest rates, repayment terms ranging from 5 to 15 years, project security requirements ranging from project equipment to other assets of the developer or sponsor, and various types of guarantees or contractual requirements Commercial banks may finance construction projects also, either during the construction stage or after it is complete The public sector banks like the State Bank of India, Industrial Development Bank of India, Industrial Finance Corporation of India, and others come under this category

Insurance companies

Insurance companies have traditionally been excellent sources of financing capital projects and may be interested in cogeneration Insurance companies are generally willing to provide longer terms for financing, ranging from 15 to 20 years. They may be willing to take equity positions in certain projects, in addition to providing debt financing Insurance companies are also likely to be willing to take somewhat higher risks than conventional banks, as long as appropriate rewards are available to them to cover the risks taken These are the Life Insurance Corporation, General Insurance Corporation of India, and others

Third-party financing

This type of financing is being practised mostly in the US. Considering the high interest rates prevalent in India, a number of third-party financing companies have been established for the explicit purpose of financing cogeneration projects The idea of BOOT/BOT/BOO is also applicable under similar conditions These companies have access to a number of different financing sources and are actively searching for cogeneration projects with the right types of economic returns Third-party financing has ranged from less than $1 million to several million dollars for some projects Quite often, these third parties have technical knowledge of cogeneration, as well as expertise in the institutional aspects of cogeneration, particularly with respect to state and federal regulations and contract negotiations with utilities and other parties. Also, these developers can take advantage of the available tax benefits and are able to pass some of the benefits to the project sponsors Third-party financing companies are willing and interested in equity positions in projects, and there have been projects selling the project outputs to an industrial firm and/or a utility.

These types of developers are quite willing to structure innovative financial arrangements that may benefit all the parties involved in the cogeneration project. During the last several years, an increasing number of large organizations are expressing interest in third-party financing, and are actively searching for opportunities to finance cogeneration projects This is now actively being considered in India also.

Individual investors

Owing to a number of tax benefits offered by cogeneration projects, individual investors represent a potential financing source Limited partnerships can be structured to provide tax benefits, cash flows, and potential long-term value to individual investors Individual investors will generally require a greater return on their equity, but at the same time they are more willing to take greater risks and to receive their returns over a long term, as long as some immediate tax benefits are available in the short term

Equipment manufacturers

Manufacturers of cogeneration equipment such as boilers, turbines, and generators are increasingly looking to the cogeneration market for the sale of their products. They have recognized that financing such equipment may increase their chances of making the sale to project developers or sponsors Manufacturers are, therefore, increasingly providing finance to cogeneration projects Some manufacturers have even set up cogeneration financing companies, specifically offering equity and debt financing to cogeneration projects In the process, they have become *full service* companies, which will provide a range of services including feasibility analysis, design, financing, construction, operation, and maintenance. Several firms in India are now con-

sidering this seriously. In fact, two turbine manufacturers are already having small-scale power plants under their scheme.

Architect/engineering firms

A number of large architect/engineering firms, who have traditionally provided services to central station power generation markets, are now turning their attention towards the cogeneration market. They too have recognized that if they offer other services such as financing, their chances of making a sale may increase These types of organizations are willing to take equity positions in projects and are interested in providing a number of different services besides design and construction management.

Industrial development authorities

For cogeneration projects owned by municipal or public authorities, tax-exempt financing through industrial development banks may be feasible The advantage of such financing is that the debt cost may be reduced substantially over conventional financing methods The ability to qualify for tax-exempt financing depends on the satisfaction of a number of complex state and central government regulations

Requirements of financing sources

The cogeneration project developer or sponsor must be aware of the major requirements of the financing sources. The most obvious and the most critical requirement of a financing source is that the basic project is economically viable In other words, the project must generate sufficient cash flow to pay all the project expenses, plus the interest and debt payments, as well as a return on the investment of the equity participants The second major requirement is that the project risks are minimal Most financing organizations want a reasonable assurance that the project interest and debt payments will be met in the future Cogeneration projects involve a number of risks If these risks are considered to be significant, then the financing organization will insist on resource financing, requiring the project sponsor to commit his other assets or resources as collateral for the project in case of default on debt payments In order to minimize the risks and provide protection against long-term uncertainties, financing organizations will generally require long-term protection In other words, it will be important for the developer to obtain contracts for his purchase of fuel, as well as for the sale of the thermal and electric energy, such that the long-term prices and costs are bound within certain limits If such contract protection cannot be obtained, financing sources may consider the project inherently risky, and may require other types of protection to assure that the interest and debt repayments will be met by the project developers.

In risky situations, financing sources will look for a debt coverage ratio of the order of 200%, i e , the anticipated net cash flows (project revenues minus all project expenses) should be twice the anticipated interest payments and debt repayments If the anticipated revenues and costs are guaranteed through contract protection, then the debt coverage ratio can be smaller

A final requirement for financing sources is the sharing of benefits proportional to the risks Higher the risk transferred to it, greater the returns expected by the financing source Therefore, projects involving substantial risks may elect to obtain equity participation by various types of organizations or to establish limited partnerships with investments by individual investors, who are willing to take higher risks

Risks and risk containment

A cogeneration project is subject to a number of varied risks Some of these are summarized below

Design and technology

Will the proposed design and technology perform as anticipated at the appropriate efficiency levels?

Construction costs

Will the project be constructed within the estimated costs?

Timing and completion

Is the project subject to significant delays or will it be completed within the schedule as anticipated?

Fuel supply and cost

Will the required fuel supply be available in sufficient quantities and without significant escalation in costs?

Sale prices and quantities

Will there be an adequate market for the sale of cogeneration products, and will the market accept the prices that are anticipated?

System performance

Will the various components of equipment in a cogeneration project perform as anticipated, and produce the required outputs for the designated level of inputs?

Operating costs

Are the operating costs subject to unforeseen escalations?

Financing costs

Are the financing costs controlled, or is there a risk that these costs might escalate if economic conditions change?

Tax regulations

Will the anticipated tax benefits actually be available, or would changes in tax regulations remove some of these benefits?

Regulatory and environmental risks

Are there any significant changes in environmental or other regulations anticipated during the life of the project that may make the project unacceptable to regulatory authorities?

While all these risks cannot be totally eliminated, it is important to limit or contain these risks so that both the project developer and the financing organization are comfortable with the level of risk faced by each, relative to the returns anticipated. Typical methods that have been used to contain risks are summarized below

Design and technology risks

Obtain quality participants, who are knowledgeable regarding cogeneration technologies and design considerations

Construction costs

Obtain insurance coverage against cost escalation, or assign fixed price contracts with the construction management firm.

Timing and completion risks

Obtain insurance protection or contract protection to assure that the project is completed on time

Fuel supply and costs

Sign long-term contracts with fuel suppliers.

Electric and thermal sales

Obtain long-term contract protection by signing contracts with the purchasers of electricity and thermal energy.

System performance

Obtain performance guarantees from the manufacturer, or insurance coverage from appropriate insurance companies

Operating costs

Obtain recognized and reputable design engineers, who are knowledgeable of the appropriate technologies being used

Financing costs

Negotiate appropriate arrangements with the financing sources so that escalations of financing costs are minimized

Tax regulations

Keep track of current trends in regulatory initiatives at both the central and state levels

Environmental and other regulations

To keep track of the appropriate regulatory changes anticipated and also knowledge of environmental and other regulations relevant to the cogeneration project

It is important to recognize while addressing risks and risk containment methods that the requirements of the project developer or sponsor and those of the financing source may, at times, conflict For example, the financing organization would require a long-term contract for the sale of electricity to the utilities, while from a project developer's viewpoint, the cost of negotiating such a contract may be significant, both in terms of legal fees and the time required to negotiate such a contract The ENRON project in Maharashtra is a case in point The negotiation of a fixed price construction contract may increase construction costs because the construction management organization will load the risks of the fixed price onto its pricing Owing to such potential conflicts, it is important that the project developer/sponsor work very closely with the financing organization in structuring the project and in designing the risk containment methods, so that the overall project risks are minimized at the lowest possible cost to the developer and the financing organization

Financing agro-industrial projects in developing countries

Marian J Mitch and Robert A Miller, FC Schaffer & Associates, Inc

To initiate any project which will require funding from external sources, a feasibility study is required which has been thoroughly researched from a technical and economic point of view and presented in a clear and concise format which allows lending institutions to arrive at conclusions based on valid information

Very basic questions to be answered in the study are as follows

- Does the project make sense? Economic, financial, and technical?
- Does the project serve a need for the country?
- What are the socio-economic effects of the project?
- Is there a legitimate need for the project—for internal consumption, import substitution, export materials or foreign exchange earnings?
- Is there a market for the product?
- Is product pricing realistic—without subsidies and can the earnings service the debt?

The feasibility study

On the majority of our projects over the last 20 years, FC Schaffer and Associates (FCS&A) has arranged or assisted in arranging the project financing Naturally, the first step is performance of the feasibility study or project evaluation This aspect too can be financed from a variety of sources, depending upon individual circumstances (such as project location, project sponsors, etc.) in the form of non-recourse grant funding, partial-recourse grant funding, or cost-sharing mechanisms FCS&A has successfully arranged, in the last ten years, over $2 5 million in non-recourse grants for feasibility studies/project evaluations of this type which in turn served to procure project financing

Feasibility studies for project consideration by lending institutions normally should include all or most of the following information

- Brief description of project
- Sponsorship, management and technical assistance, history and business of sponsors, including financial information, proposed management arrangements, names, and curricula vitae of managers, and description of technical arrangements and other external assistance (management, production, marketing, finance, etc.)
- Market and sales
  Basic market orientation—local, national, regional or export; projected production volumes, unit prices, sales objectives, and market share of proposed venture; potential users of products

and distribution channels to be used; present sources of supply for products; future competition and possibility that the market may be satisfied by substitute products, tariff protection or import restrictions affecting products; and critical factors that determine market potential

- Manufacturing process and availability of resources
  Description of manufacturing process; comments on special technical complexities and need for know-how and special skills, possible suppliers of equipment, availability of manpower and infrastructure facilities, transport and communications, power, water, etc ,, breakdown of projected operating costs by major categories of expenditures, source, cost, and quality of raw material supply and relations with support industries, import restrictions on required raw materials, proposed plant location in relation to suppliers, market, infrastructure, and manpower, and proposed plant size in comparison with other known plants
- Investment requirements, project financing, and returns
  Estimate of total project cost, broken down into land, construction, installed equipment, and working capital, indicating foreign exchange component, proposed financial structure of venture, indicating expected sources and terms of equity and debt financing, type of financing—loan, equity, or both, and amount, projected financial statement, information on profitability, and return on investment, and critical factors determining profitability
- Government support and regulations
  Project in context of government economic development and investment programme, specific government incentives and support available to project, expected contribution of project to economic development, and outline of government regulations on exchange controls and conditions of capital entry and repatriation
- Time scale envisaged for project preparation and completion
  A completed project schedule/bar chart showing all phases/events of the project from beginning to end

The project

If the results of the feasibility study are favourable, funding sources are approached with applications for preliminary commitments A few examples of funding sources, broken down by types are given

International and multi-lateral institutions

- World Bank group
  International Development Bank
  International Finance Corporation
  Multi-lateral Investment Guarantee Association
- Asian Development Bank
- Inter-American Development Bank
- African Development Bank
- Caribbean Development Bank
- Central American Bank for Economic Integration
- Corporation Andino Formento
- European Bank for Reconstruction & Development
- East African Development Bank

Governmental export credit agencies

- Export Import Bank of the United States
- Export Credit & Guarantee Department (UK)
- COFACE (France)
- HERMES (Germany)
- Import Export Bank of Japan
- SACI (Italy)

Investments

- International Finance Corporation (World Bank)
- Overseas Private Investment Corporation (US)
- Commonwealth Development Corporation (UK)
- FMO (Netherlands)
- DEG (Germany)
- Industrialization Fund for Developing Nations (Denmark)
- Asian Development Bank, Inter-American Development Bank and African Development Bank all have private sector investment entitlements

National aid organizations

- US Agency for International Development - USAID
- Japan International Cooperation Agency - JICA
- Kreditanstalt fur Wiederbaufau - KFW (Germany)
- Dutch Aid (Netherlands)
- Caisse Central (France)
- All Scandanavian countries have aid programmes for developing countries.

Institutions and lenders will look at the feasibility study to ascertain if the project fits specific guidelines to enable a positive response for a commitment for project financing In addition, they will be concerned with the financial plan with regard to the following

- Are the projections realistic?
- Are they of a conservative nature?
- What is the capital contribution of the project sponsor?
- What is the total amount of borrowing?
- What are the capital costs, as well as the operating costs?
- What are the price projections?
- What is the debt/equity ratio?
- Is there a positive cash flow?
- How is the debt service covered?
- Foreign exchange to repay the debt

Institutional issues examined include the following

- economic impact of the project,
- environmental impact of the project,

- social impact,
- labour (How many jobs does the project create for local people?), and
- internal rates of return shown on the project

It should be noted that institutions place high emphasis on the internal rate of return (IRR) as the basis of their decision, while lenders use the debt service coverage Ratio as the basis of their decision

Other lender considerations are

- size of the project,
- share of the loan if other lenders are involved,
- lender's share of the risk,
- timing and sequence of the internal approval process, and
- prestigious firm syndrome

Approval process

Based on our prior experience with projects being financed by institutions and other various lending services, we must stress that patience is a virtue The process can be extremely lengthy—sometimes the entire cycle can take up to two years Persistence is equally important Approval of applications and commitments can be summarized as follows

- negotiations of the credit agreement,
- actual loan agreement,
- any conditions/precedents stipulated by the institution must be met prior to any disbursements,
- government approvals (government guarantees may be required and sometimes various branches of the local government are involved This approval process can sometimes be extremely lengthy depending on the branches involved, scheduled sessions, etc),
- actual disbursement of the loan proceeds and logistics to be worked out, and
- implementation and monitoring of the project by the institution reporting process can be tedious

Nevertheless, persistence and patience can certainly prevail FCS&A has been successful in bringing project financing and projects to fruition for over 25 years In the last ten years, we have arranged or assisted our clients in arranging over $80 million of project finance, much of which was secured at concessionary rates. A few cases are summarized below

East Africa cases

- Long-term development/client interest commenced in 1976
- Client studied the competitor situation of established companies with longstanding commercial and government relations
- Invitations to perform the study were released in late 1985

- Competitive bids were received and evaluated with highest technical ranking and price in comparable ranges
- However, at this point, the local entity discovered it would require funding.
- Bidders were advised they could be awarded the project, provided funding was arranged.
- Funding with US Trade & Development Program (TDP) was arranged in August 1986 for the feasibility study.
- Study was executed in the fall of 1986
- Development of the project financing package with US Exim Bank commenced in late 1986
- Spring 1987—approval of the project was granted on a technical level and a contract was signed for the execution of the project pending finalization of the financing package.
- Summer of 1987, through end of 1987—approval process of financial package was finalized.
- Financial agreement completed, parliamentary approvals granted and signed in mid-1988.
- Project commences in late 1988

Another example of project FCS&A is assisting in arranging financing in East Africa is given below.

- Client's interest in rehabilitation of an existing facility commences in 1988.
- FCS&A submits proposal to conduct study in late 1988
- FCS&A wins the project study based on its ability to bring grant funding.
- Applications are filed for funding with US TDP in 1989
- Funding approved in mid-1989
- Grant agreements between client and US TDP signed and contract between FCS&A and client executed in late 1989
- Study is performed in early 1990 and finalized in mid-1990.
- Applications filed in mid-1990 for project financing commitments
- Project fits US Exim Bank's guidelines and conditions for financing and commitments issued in early 1991.
- Client begins process of approvals and arranging down payment mechanism in early 1991.
- Final contract negotiations held in late 1991.
- Project start date, 1992

Additional projects in which FCS&A has successfully arranged financing and/or project commitments are given below

- Value of purchased power
- Continuous firm power as available, dependent upon factory down time, length of crop, residual feedstock after the crop, etc
- Capacity required by the electric company to supply its customers.
- Dispatch availability
- Emergency power availability
- Outside fuel costs.
- Operations and maintenance costs.

Avoided cost, on a worldwide basis, is presently averaging US cents 8/kWh. The low in the US, such as Louisiana, is US cents 2/kWh, with a high in developing countries, such as Belize, at US cents 11 per kWh

Some of the key items in a power purchase contract are as follows:

- parties to the contract,
- warranties and guarantees as regards supply of power,
- ownership of power,
- specific interconnect points,
- rights and duties,
- payment terms, and
- payment currency.

Attached is an example of a power purchase agreement.

Currency is a major item for consideration as regards the availability of foreign exchange to service the debt. If payment is in local currency, then the Central Bank in-country becomes a major player. As the key issue is availability of foreign exchange, the Central Bank can either commit to making the hard currency available or undertake to provide the foreign exchange. Great care should taken if only an undertaking is issued by the Central Bank, as this simply means that they will undertake to make this currency available. It does not commit the foreign exchange to service the debt, and the borrower and guarantors will then have the burden with the lenders for the project

In summary, financing agro-industrial projects is a reality worldwide. With proper guidance, know-how and a favourable, bankable feasibility study/project appraisal by a reputable firm, patience, and persistence, a project with potential can be delivered. We invite any queries you may have and are happy to investigate finance possibilities for any potential projects you may have in planning stages

Tentative power agreement between plantation suppliers and the electric co., ltd

THIS AGREEMENT made this day of. .. .. by and between SUGAR COMPANY, LIMITED, a Hawaii corporation,. ... PLANTATION COMPANY, LIMITED, a Hawaii corporation... .SUGAR COMPANY, LIMITED, a Hawaii corporation, and FARM COMPANY, a Hawaii corporation (hereinafter called the "Suppliers"), and . ELECTRIC COMPANY, LIMITED, a Hawaii corporation (hereinafter called the "Consumer")

WHEREAS, the Suppliers, as an incident to the growing and milling of sugarcane, own and operate electric power plants wherein they generate the electrical power required of their respective operations and in addition are capable of generating electric power in excess of their current needs, and

WHEREAS, the Consumer is desirous of purchasing from Suppliers electric power as hereinafter provided,

NOW, THEREFORE, in consideration of the mutual promises contained herein, the parties hereto agree as follows.

1 Upon and subject to the terms and conditions hereinafter set forth, Suppliers agree to sell and deliver and Consumer agrees to purchase and pay for electric power as hereinafter described for the period beginning as of the date of this contract and continuing until and including and thereafter from year to year unless this agreement shall be terminated by any of the parties hereto by the giving to the other parties hereto of six months' written notice of intention to terminate the same, provided, always, that no such notice shall become effective prior to

2 All electric power shall be delivered at the points designated as follows within the County of Kauai, State of Hawaii, and at the voltages, phases, and cycles herein below provided:

Lihue substation	11500 Volts	3 Phase	60 Cycle
Lawai	11500 Volts	3 Phase	60 Cycle
Wainiha	2300 Volts	3 Phase	60 Cycle
Kalaheo	11500 Volts	3 Phase	60 Cycle
Kekaha	4160 Volts	3 Phase	60 Cycle
Kekaha	6900 Volts	3 Phase	60 Cycle
Koloa substation	11500 Volts	3 Phase	60 Cycle
Puhi tap	57100 Volts	3 Phase	60 Cycle
Kokee tap	6900 Volts	3 Phase	60 Cycle

Additional points of delivery and the voltages to be delivered therefrom may be designated as agreed upon between the parties

3 The Suppliers shall have available upon reasonable notice, and shall deliver to Consumer upon request, such electric power as Consumer may request up to a maximum annual consumption of 150 000 kWh and to an aggregate peak or maximum load of 27 000 kW. Said peak or maximum load shall be computed by totalling the individual average measurements obtained from each and every demand meter which measures any electric power delivered by any of the Suppliers to the Consumer throughout any designated sixty-minute period

4 Suppliers reserve the right to supply demands of the Consumer within the limits of paragraph 3 above as they in their sole discretion see fit, PROVIDED, HOWEVER, that unless Consumer is otherwise notified SUGAR COMPANY, LIMITED (" ") shall supply approximately 8%, SUGAR COMPANY, LIMITED (" ") approximately 20%, PLANTATION COMPANY, LIMITED (" ") approximately 61%, and FARM COMPANY (" Farm") approximately 11%, of the electric power requested by Consumer pursuant to this agreement This approximate 8-20-61-11 is to be maintained at all normal times during the grinding season, from 1 February to 31 October, inclusive, except that by mutual agreement among all the Suppliers, this ratio may change from time-to-time as provided in the Suppliers Agreement Governing Joint Operations, attached hereto as an Appendix

5 All electric energy delivered and paid for pursuant to this agreement shall be measured by meters owned and maintained by the Consumer, and the readings of such meters shall be conclusive upon the parties hereto unless, upon being tested, such meters shall be found to register inaccurately, and the inaccuracy shall exceed two per cent; in which event the amount of the electric energy delivered through such meters shall be computed by applying to the appropriate meter reading or readings a correction factor determined by accurate tests Any meter shall be promptly tested upon request of any of the parties hereto, and any of the parties hereto shall have the right to participate in and check such tests.

6 The loss of electric power suffered in any particular electric system shall be borne by the owner of the said system, provided, however, that where any of the Suppliers may deliver electric power to a delivery point from whence said power flows directly to one of the Consumer's transformers and the Consumer meters, said power on the low side of said transformer, then and in such an event, the Consumer shall suffer any and all power loss caused by the said transformer, and such lost energy shall be considered as delivered electric energy for purposes of paragraph 7b hereof. All of such transformer losses shall be verified by Suppliers and unless the computations for the previous billing period are challenged by the Suppliers within ten days after the presentation of the monthly payment and related computations, the said computations and payment shall be conclusively presumed to be correct

7 Except as provided in paragraph 8, the monthly charge for the electric energy delivered pursuant to this agreement shall be as follows

a The Consumer shall pay a demand charge of $2 75 per kilowatt for the 60 minute aggregate maximum demand recorded during the said month, said maximum or peak kilowatt load to be computed as provided in paragraph 3 above.

b Subject to adjustment as hereinafter provided, the Consumer shall also pay a basic energy charge of three-quarters of a cent per kilowatt hour delivered The foregoing price is based upon an average monthly posted price of $2 00 per barrel for standard bunker fuel oil delivered by the Standard Oil Company of California, or any other oil company, to Suppliers at such oil company's plant on the Island of Kauai. It is expressly agreed that if the true average monthly posted price for oil company deliver to the plant from a said bunker, fuel oil shall be less than, or exceed, $2.00 per barrel, the foregoing price of 0.75 cents per kilowatt hour shall be decreased or increased in the amount of 0 003 cents per kilowatt hour for each 1 cent, decrease or increase in the price of said bunker fuel oil. The true average monthly posted price for oil company plant delivery of said bunker fuel oil shall be computed on the basis of the posted price per day for each and every day of the applicable calendar month

c The basic energy charge defined above in paragraph 7b shall be applicable to all energy delivered to the Consumer during the off-season, from 1 November to 31 January, inclusive

d A charge equal to 85% of the basic energy charge defined above in paragraph 7b shall be applicable to all energy delivered to the Consumer during the grinding season from 1 February to 31 October, inclusive, except that during any period of 7 days or longer duration in which the Suppliers' normal plantation operation may be interrupted by war, strike, local or national emergency, or for any other reason beyond their control, the basic energy charge of paragraph 7b shall apply

e Notwithstanding the above rates of charge for demand and energy, the Consumer's aggregate total annual payment to all the Suppliers for service under this agreement in any calendar year shall not be less than 90% of the aggregate total annual payment made in the preceding year.

8 and Farm shall continue to supply electric energy to the various small outlying plantation camps which they currently service and where power is not metered on a demand and energy basis. Payment for all electric energy supplied to the said camps pursuant to this paragraph shall be made to Kekaha and Grove Farm at the fixed rate of 2 cents per kilowatt hour

9 The Consumer will compute the monthly payment due to each Supplier in accordance with the principles and practices outlined in paragraphs numbered 10 through 22 of the Appen-

dix entitled Suppliers Agreement Governing Joint Operations for Furnishing Electric Power to . Electric Company, Ltd, or as that agreement may from time-to-time be modified by mutual consent of the Consumer and all Suppliers. All basic data, computations, and payments shall be reviewed and approved by a representative appointed by the Suppliers for this purpose and a copy of the approved payment computation shall accompany the payment made to each Supplier Payments shall be made not later than the 15th day of each calendar month for service rendered during the preceding calendar month.

10 All electrical loads will be scheduled and cleared by the Consumer's System Load Dispatcher in the System Operations Center Consumer's System Load Dispatcher shall furnish to each Supplier at said Supplier's principal office lists of all anticipated hourly peak loads to be supplied at least 30 days in advance of delivery; provided, however, that unexpected scheduling of loads shall be handled on short notice. In scheduling the anticipated loads, Consumer shall separately list the anticipated loads for each delivery point

11 In the event that the Consumer during the term of this agreement should enter into a contract with some other party which is not a party to this agreement, providing for the purchase of additional electric power, Consumer expressly agrees that it will not order or take delivery of any of said electric power without first ordering and taking delivery of all of the electric power which Consumer may legally demand of Suppliers under this agreement. This covenant shall not be applicable to present commitments of Consumer where power of Suppliers is not available

12 Any other term, covenant or provision herein contained to the contrary notwithstanding, if any of the Suppliers shall be wholly or partially prevented from delivering the electric power contracted for herein, or if the service thereof shall be interrupted, or if the Consumer shall be prevented from receiving, using, and applying the same, by reason of or through strikes, shortage of labour, riot, fire, flood, invasion, insurrection, accident, the order of any court, judge or civil authority, any act of God or any cause reasonably beyond their exclusive control and not attributable to their neglect, then and in any such event, Suppliers shall not be obligated to deliver said electric power hereunder during such period and shall not be liable for any damage or loss resulting from such interruption or suspension, and Consumer shall not be obligated or liable to take or pay for any such power during such period In any of such event or events, the party or parties suffering such interruption or suspension shall be prompt and diligent in removing the cause thereof.

13 Consumer shall not, without the prior written consent of Suppliers, assign any interest it might have in this agreement, provided, however, that in the event of a sale, transfer or foreclosure of Consumer's electric systems or business, then and in any such event this agreement may be assigned without the prior consent of Suppliers Nothing herein contained shall be construed to prevent the resale of any electrical power by Consumer to any third party or parties.

14 Any other term, covenant or provision herein contained to the contrary notwithstanding, this agreement shall not be construed in any manner so as to benefit any third party; nor shall it be construed in a manner such as to place Suppliers in privity with any parties who might have a contract to purchase electric power from Consumer, nor shall it be construed in any manner so as to impose a duty upon any of the Suppliers to supply electric power to any portion of the public or to any private person or parties, not a party to this agreement, or to supply electric power to any particular locality or district in the County of Kauai.

15 In the event that any existing or hereinafter enacted legislation of whatsoever kind and nature, when reasonably construed, purports to classify any Supplier, as a public utility or to

impress upon any of the Suppliers' property any degree of public interests, or in the event that this agreement be construed so as to make Suppliers or any of their property subject to the provisions of Chapter 104, Revised Laws of Hawaii 1955, then and in any such event any of the Suppliers hereto so affected may at its option forthwith or any time terminate this agreement.

16. Should a question arise between any two of the parties hereto as to the construction, meaning, or effect of this agreement or any portion thereof, then and in such event the difference shall be resolved by three arbitrators who shall have all of the powers of authorized arbitrators by Chapter 188, Revised Laws of Hawaii 1955, as the same now is or from time to time hereafter may be amended, one of the arbitrators shall be appointed by each of the parties to the disagreement and either such party may give to the other written notice of a desire to have a determination of such difference and name therein one of the arbitrators, whereupon the other party shall, within 10 days after receipt of such notice, name the other arbitrator and give notice thereof to the party desiring such determination, and in case of failure to do so, the party who has first named an arbitrator shall have the right to apply to the Circuit Court of the First Judicial Circuit of the State of Hawaii to appoint an arbitrator to represent the party failing to appoint an arbitrator, the two arbitrators thus appointed (in either manner) shall select and appoint a third arbitrator, and give notice thereof to both parties, and in the event the two arbitrators so appointed shall select and appoint a third arbitrator, and give notice thereof to both parties, and in the event the two arbitrators so appointed shall within 10 days after the naming of the second arbitrator fail to appoint the third arbitrator, either party may apply to and have such arbitrator selected and appointed by the said Court and the three arbitrators so appointed shall thereupon proceed to resolve the said difference and the decision of any two of them shall be final, conclusive and binding upon all of the parties hereto unless the same shall be vacated, modified or corrected, all as provided in Chapter 188, Revised Laws of Hawaii 1955, aforesaid.
17 This agreement and each and all of its covenants, terms, and provisions shall be binding upon and inure to the benefit of the parties hereto, and their respective successors and permitted assigns, whether hereinabove so expressed or not

IN WITNESS WHEREOF, the parties hereto have executed these presents as of the date above written.

Appendix

Suppliers agreement governing joint operations for furnishing electric power to electric company ltd.

In order to give effect to the Power Agreement made this day of by and between . Sugar Company, Ltd., a Hawaii corporation, Plantation Co , Ltd, a Hawaii corporation, ... Sugar Co , Ltd., a Hawaii corporation, and Farm Company, a Hawaii corporation (hereinafter called the "Suppliers"), and Electric Company, Ltd , a Hawaii corporation (hereinafter called the "Consumer"), the aforementioned companies comprising the "Suppliers" do hereby covenant and agree among themselves to act jointly and severally to sell and deliver to the Consumer electric power in the amounts required to serve its connected load at all times within the contract period, up to a maximum total annual energy requirement of

150 000 000 kilowatt hours and up to a maximum 60 minute aggregate total demand of 27 000 kilowatts

For this purpose, the undersigned Suppliers agree to be governed by the following principles and practices in regard to electric generating plant facilities, operations, maintenance, load-sharing, and revenue distribution, or to such modifications or additions to these as may be adopted from time-to-time by mutual agreement among the undersigned Suppliers

1 In general, the four Suppliers will share in supplying the Consumer's load, and in the division of revenue resulting therefrom, in proportion to the basic participation ratios derived from their "bagasse-based" capability", where these terms have the meaning and intent vested in them by the .... .. Inc , Report entitled "Electric Power Supply on the Island of Kauai", dated 31 March 1966

2 Initially, the basic participation ratios for the several Suppliers are as shown below. These are predicated upon the assumption that Sugar Co will normally operate its steam power plant facilities on a 5-day weekly schedule, and reflect the respective bagasse-based capability of the several Suppliers during the grinding season beginning 1 February 1968

Suppliers	%
Plantation Co , Ltd	60 5
Sugar Co , Ltd	20 6
Sugar Company, Ltd	8.0
Farm Company	10.9

3 The basic participation ratios are subject to revision effective on the first day of each year following the first anniversary of this agreement. In general, a revision of these participation ratios will be the consequence of a major change in power generating facilities, plantation operations, or production levels of one or more Suppliers Request for consideration of a change in any Supplier's participation ratio must be made not later than 30 September in any year in order that it may be made effective on 1 January next following. Adoption of a modified array of participation ratios to replace those stated above requires the written consent of all four Suppliers furnished in the form of a rider to this initial Agreement.

4 For the purpose of this Agreement, the "grinding season" is defined as the period from 1 February to 31 October, inclusive, in every year, and the "off-season" represents the balance of the year, 1 November to 31 January, inclusive. Similarly, the five day weekly schedule relates basically to the period from 2 pm Monday afternoon to 2 pm on Saturday afternoon and accords generally with Supplier's normal weekly period of plantation operations. Plantation operations of individual Suppliers may deviate from these schedules in various ways from time to time, but such deviations shall not modify their obligation to share in supply to the consumer at all times in accordance with the stated participation ratios.

5 All electrical loads representing supply to the Consumer will be scheduled and cleared by the Consumer's System Load Dispatcher The Consumer will furnish to each Supplier, at least 30 days in advance of delivery, a list of anticipated hourly loads to be supplied. Such hourly load schedules will be based upon the participation ratios set forth above, or as they may be revised from time to time Each Supplier shall exercise utmost diligence and care to adjust the total power export from his electric generating facilities to accord within reason-

able limits with the established loading schedule; subject, however, to such immediate changes in export power as the Consumer's System Load Dispatcher may direct in order to meet unexpected or emergency load situations.

6. Based upon the varying magnitude of total Consumer load over the daily load cycle, during both weekdays and weekends in the grinding season and in the off-season, the Suppliers will schedule operation of their several hydroelectric generating units and steam-turbine generating units so as to maintain a total capacity in operating generators at least equal to the Consumer's total load plus the capacity of the largest single electric generating unit then in operation among the several Supplier's power plants
7. Each Supplier shall keep a log of power plant operations to record start-up and shutdown of electric generating units, loading changes dictated by schedule, and those which may be directed by Consumer's load dispatcher, as well as hourly meter readings showing power export All such data shall be reported or confirmed to Consumer's System Load Dispatcher without delay for entry on the Consumer's daily system operation log sheet
8. Emergency situations, such as automatic or forced manual shutdown of generators, boilers, or other vital power plant equipment within any Supplier's plant, including Consumer supply feeders or buses, shall be reported immediately to the Consumer's System Load Dispatcher Under such circumstances, and as requested by Consumer's System Load Dispatcher, all other suppliers shall increase their power export above their scheduled loadings to offset the system capacity so lost. The "other" Suppliers mentioned above may be required at times to reduce their own in-plant load for a brief period in order to respond immediately to the Consumer's need for replacement power The Consumer will operate his standby diesel-engine generator facilities up to their 3000 kW rating at such times to assist the Suppliers in meeting the total requirements of the Consumer's load, but such engine operation by the consumer shall not extend beyond 12 hours As soon as possible after the emergency condition arises, the Suppliers shall arrange among themselves to offset any deficiency in some one Supplier's individual power export capability
9. Each Supplier shall adjust the voltage level of his main generators to accord with the requirements of the Consumer in maintaining proper voltage conditions, power factor, and reactive power flow throughout the system Generally, this will take the form of a regular schedule of bus voltage variation for weekdays and weekends, but from time to time abnormal system conditions may require the Consumer's System Load Dispatcher to direct one or more Suppliers to adjust bus voltage to a higher or lower value for a prescribed period of time.
10. The Supplier carrying the largest load assignment shall be responsible for holding system frequency and for periodic adjustments to correct time on the system.
11. The consumer will install and maintain integrating watt hour meters and 60-minute recording demand meters of suitable type at all supplier delivery points to serve as billing meters. The consumer will consolidate the demand meter chart data to establish the coincident or aggregate monthly maximum demand for all Suppliers The Consumer will consolidate the integrating watt hour meter readings to measure the total energy delivered by each Supplier. All billing meter data shall be read and recorded regularly on the last day of the month.
12. The Consumer will compute the payment due to each supplier in accordance with the principles outlined in the numbered paragraphs which follow. A representative appointed by the Suppliers shall review and approve such computations for the Suppliers before payment is made. A copy of the approved payment computation shall accompany the payment to each Supplier.

13 Each Supplier will receive payment for all kilowatt hours of electric energy delivered to the consumer and metered at the Suppliers' respective delivery point or points. Such payments will be computed using the standard energy charge rate adjusted for delivered cost of fuel, during the off-season, that is, from 1 November to 31 January During the grinding season, payment for all kilowatt hours of electric energy will be computed in the same general manner as above and multiplied by the factor 85/100ths (0.85)

14 Monthly maximum demand charges will be based upon the actual coincident monthly maximum demand which the Consumer makes on all Suppliers as a group. Normally, each Supplier will receive payment for that portion of the monthly maximum demand determined by its respective basic participation ratio Thus, for a grinding season monthly maximum demand of 20000 kW, with all Suppliers operating on a 7-day week, demand payments would be determined as follows:

Consumer's demand payment	1.00 × 20 000 kW × $2 75 = $55 000
To	0.605 × 20 000 kW × $2 75 = $33 275
To	0.206 × 20 000 kW × $2 75 = $11 330
To	0.080 × 20 000 kW × $2 75 = $ 4 400
To Farm	0.109 × 20 000 kW × $2 75 = $ 5 995
Total	$55 000

15 Distribution of the Consumer's total monthly maximum demand payment among Suppliers, when one or more Suppliers operate part time or at some level of participation other than the basic participation ratio, shall be based on the services rendered In general, the basis of compensation between Suppliers when one Supplier undertakes a portion of another Supplier's obligation to furnish capacity shall be one-twenty fifth of the regular monthly demand payment per kilowatt for each day or fraction of a day that the arrangement continues All such departures from the regular schedule of loading defined by the basic participation ratios then current, shall be authorized (or confirmed) in written memorandum given to the Consumer's System Load Dispatcher by both Suppliers party to the agreement

16 Any Supplier, with the agreement of all other Suppliers, may elect to operate his steam-electric generating facilities on a specific schedule of less than a seven day week, providing that it will not jeopardize the reliability of electric power supply to the Consumer, and providing that he will maintain such electric generating equipment in readiness for 4-hour start-up, and agrees to place it in operation on such short notice during periods of system emergency

17 Any Supplier, with the agreement of all other Suppliers, may elect to shut down his steam-electric generating facilities during the off-season, from 1 November to 31 January, subject to the same provisions as cited in paragraph 16 above relative to start-up and operation during periods of system emergency

18. Under system emergency conditions, all Suppliers will cooperate to the fullest extent possible and exercise their best efforts to maintain uninterrupted supply to the Consumer's system. All energy delivered to the Consumer will be paid for as metered. Incidental departures from customary loading practice in accord with basic participation ratios, shall be tolerated for periods up to 12 hours without requiring reassignment of monthly maximum demand payments.

19. Emergency operations shall not continue beyond a period of 12 hours. Prior to expiration of that time limit, the Supplier responsible for the deficient capacity shall start up alternative equipment or make suitable arrangements to have another Supplier make up the deficiency

and receive appropriate compensation until such time as normal loading practices can be resumed.

20. For short-term relief attending major equipment overhaul, or as a result of equipment failure, any Supplier may arrange for another Supplier to furnish a specific block of capacity in his stead. Notice of such arrangements shall be given to the Consumer's System Load Dispatcher who will be guided thereby in making load assignments. Distribution of maximum demand payments by the Consumer will continue, as before, to accord with the basic participation ratios. Any arrangement for compensating the second Supplier for the substitute capacity will be the business of the two Suppliers involved

21 For part-time operation, such as a five-day week, and excluding holiday operation, the unit monthly maximum demand payment of $2 75 per kilowatt received from the Consumer will be divided on the approximate basis of five-sevenths, with $2 00 per kilowatt per month paid to the part-time Supplier for five day participation in supply, and the balance redistributed among all other seven-day Suppliers on the basis of their respective participation ratios, as shown below for a 20 000 kW monthly maximum demand.

Consumer's Demand Payment	1.00 × 20 000 kW × $2.75 = $55 000
To	0.605 × 20 000 kW × $2.75 = $33 275
To	0.206 × 20 000 kW × $2.00 = $8240
To	0 080 × 20 000 kW × $2 75 = $4400
To Farm	0 109 × 20 000 kW × $2 75 = $5995

Balance for Redistribution to Seven-day Suppliers : $ 3090

22. Where a Supplier elects to operate only his steam-electric generating facilities on a five-day weekly basis, continuing hydroelectric operations over the full seven days, the average net hourly production of the hydroelectric facilities delivered to the Consumer during those hours of the month in which steam-electric facilities are shut down shall determine the portion of that Supplier's monthly demand participation which will be compensated at the normal $2 75 per kilowatt rate The remainder of that Supplier's demand participation will be compensated at $2 00 per kilowatt, and the balance redistributed among all other seven-day suppliers on the basis of their consequent participation ratios

Elements of a power purchase agreement

R K Pachauri, Director Tata Energy Research Institute

The Task Force would be treating the elements of a Power Purchase Agreement (PPA), in detail. But some of the issues that must guide the design and development of a PPA are highlighted here A very good document has been prepared by Schaffer's as part of the study that they have carried out In our background material there is a draft Power Purchase Agreement which essentially covers the points discussed here.

The structure and the elements of a PPA

The first thing to do is to get a very clear idea of the rights and responsibilities of all the parties. A lot of this evolved through discussions and negotiation A sugar mill cogenerating and supplying power to a grid, basically involves these two parties—the electric utility and the sugar mill. But if a third party is involved then two sets of agreements are required, and there has to be a sort of binding framework within which both these agreements have to be designed and implemented The second point is that one needs to address the valid concerns in sources of risk and uncertainty This again is something which one could list initially, but it is really through articulation through a period of dialogue and discussions that some of these concerns and perceived risks can be addressed.

Thirdly, the agreement has to minimize grey areas and areas of dispute or conflict because otherwise one would be paying huge lawyers' bills for all time to come and that would add several cents to the cost of the power A good contract in this case is one that is signed and all the parties involved agree to It should be such that it doesn't lead to any dispute or problems in due course Now, that is an ideal situation. But this does happen in several cases. A number of contracts don't necessarily become subjects of dispute over a period.

In the case of cogeneration, the major provision of a PPA would cover a peak season and off-peak season provision and this would further go down to the issue of daily peaks and daily off-peaks and typically there will be a percentage of 10% (arbitrary figure) of the basic rate as a premium for supply during on-peak periods. Now, this again is something which is subject to negotiation and depends on the entire financial characteristics of the contract. But one needs to differentiate between peak and off-peak supply This needs to be defined in terms of the periods, base levels, and so on

A billing and payment procedure needs to be laid down The payment procedure must provide guarantees and therefore it may involve certain provisions of penalties in the event of failure. There would also normally be interest in delays in payment and in the case of a sugar mill guarantees are needed for supply of bagasse.

The equipment that has to be installed and the standards that it must be up to need to be decided because one could theoretically have a situation where the cogenerator installs equipment

which is substandard and does not give quality and reliabilities of power. Therefore, nationally, the recipient utility has every right to lay down certain standards These need to be specified and agreed on right from the beginning.

Also, an agreement on the interconnection arrangement and the interface, is needed. In the earlier session, there was a discussion on who was going to pay for it. Now this of course will become a part of the contract and irrespective of who pays for it the fact is that the cost has to be built in to the pricing arrangement and ultimately it is a cost which has to be borne by the consumer. All this needs to be spelt out and issues of interface between the cogenerator and the power company have to be addressed in technical, legal, and financial terms

The sort of protection arrangement needed for the interconnection have to be spelt out and in order to ensure that there is smooth implementation of the contract, a procedure for close liaison between the parties concerned has to be laid down because a dispute is not allowed to create problems. Essentially, the situation has to be kept within manageable levels This is best achieved if there is a proper provision for close liaison.

One requires metering arrangements with both the parties and there has to be a system by which these are tested and certified and tests are implemented to ensure that the meters function properly. A schedule is needed for commissioning of the facilities. When there is a contract, there is an implicit provision that power would be available from so and so date, and the project will be implemented by so and so date The time table on the plan for commissioning needs to be put down. That is an inherent part of the contract itself.

Other important aspects that need to be considered in the PPA are continuity of service and conditions for interruption. There are always certain conditions under which interruptions will be allowed. There is always a *force majeure* because of natural calamities or acts of God as a result of which there might be interruptions. Those need to be spelt out

The contract also requires a reporting procedure both daily and monthly, and it could have different frequency, so that there is a system by which information flows from one party to another. The duration of the contract and, in the event of failure, what kind of termination arrangement would be there needs to be specified. Normally, this is not implemented because both parties are making major commitments and investment to see that the contracts function, nevertheless one may lay down a certain clause for termination. The costs and obligation will have to be laid down.

Finally, a system by which disputes can be resolved is needed and there is generally an arbitration clause which would help to take care of any disputes and ensure that the findings of the arbitrator are binding on the parties concerned.

These are some highlights of what goes into a contract. There might be several other provisions which may be offshoots of what have been mentioned here, but in much greater element than what is presented

These are really conceptual points on which one needs to build up specific details and legal provisions that are sanctified by the law of the land and by the system under which these transfers are to take place.